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APPENDIX A

INSTRUCTIONAL DESIGN AND LESSONS IN PHYSICS BASED ON
THE MODELS OF BRUNER AND GORDON
INSTRUCTIONAL DESIGN AND LESSONS IN PHYSICS
BASED ON THE MODELS OF BRUNER AND GORDON

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2012

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Former Professor & Dean
University of Kerala
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Overview

The Instructional Design has seven phases where the principles and theories of Jerome S. Bruner and William J. J Gordon are adopted.

The tasks/activities are selected under the seven phases with a view to developing an integrated instructional model for teaching ten lessons in physics using this model are prepared.
Introduction

Physics plays an important role in health, education, economic development, energy and environment. Basic knowledge of physics is needed for the realization of future vision of our modern society. In the present technological age, teaching as well as learning introductory physics is a challenging task. The real pleasure of learning physics can be achieved only through the understanding of basic concepts in physics meaningfully and through the visualization of those concepts creatively. But unfortunately, this sort of pleasure of learning and also a high level of academic standard of students are missing in today’s teaching-learning process.

Development of concept learning process and skills in problem-solving and creative thinking is a continuous process starting from primary to master level. But present physics instruction at secondary stage provides less stress on understanding of fundamental physics concepts. Students at secondary stage also lack opportunities to achieve lifelong learning skills including problem-solving which are highly essential for innovations in the present century. So students find difficulties in understanding fundamental concepts in physics and it seems they acquire many misconceptions like “forces cause motion”, “friction is caused by surface roughness” etc., while learning physics. Students also experience difficulties in hypothesizing, inferring, analyzing unfamiliar situations and also in developing more innovative ideas. Hence, it is highly essential to develop a more interactive and creative problem-solving instructional pattern for enhancing physics learning.

Instructional Design

Recent studies indicate that effective analogies and appropriate concrete examples act as effective means of reducing misconceptions. This will help to visualize abstract concepts and to develop thinking skills (Podolefsky, 2008; Orgill & Thomas, 2007; Eryilmaz, Geban, & Yilmaz, 2006; McCoy, 1996; Hull & Fedje, 1985). Many strategies use analogies and examples as thinking tools for concept learning and also for developing creative thinking. Among these, Bruner’s (1956) concept attainment strategy was found to be an effective strategy in developing reasoning ability and in attaining concepts (Singh, 2011; Rama Rani & Kaur, 2010; Kalani, 2010). Reid (2011) reported that concept attainment lessons recommended by Joyce, Weil and Calhoun (2004) help to develop critical thinking skills of learners and
this inductive lesson structure leads learners step by step to an in-depth understanding of a new idea and scaffolds their thinking as they piece together essential attributes of the target concept.

Effective use of analogy fosters understanding and avoids misconceptions (Duit & Glynn, 1992, 1995). According to Zull (2002), analogies, metaphors, pebbles, and stories are powerful in concept learning. We cannot understand anything unless we create internal neuronal networks that reflect some set of physical relationships that accurately map the relationships in the concept (p.128). Research also showed the significant role of analogies in developing creative thinking skills. Gordon (1961) developed a strategy named as synectics for developing creative problem-solving. Synectics model uses metaphor and analogy to enhance creative power of learners.

Both convergent and divergent thinking are essential for effective productive thinker. An important goal of education is helping students learn how to think more productively by combining critical thinking and creative thinking. This can be realized by providing learning environment to integrate all parts of the brain. Infusion of both convergent and divergent thinking makes one generate better solutions to the problem. According to Joyce, Weil and Kluwin (1978) synectics, a model which is used to spark creativity, is most useful when blended with other models especially, other information processing models. Synectics model can stretch concepts being explored with other information processing models. Hence, a new instructional design is developed by integrating Bruner’s concept attainment model with Gordon’s synectics model. This integrated brain approach would help to visualize abstract concepts by removing misconceptions. This will also help to develop creative thinking skills.

**Description of the Instructional Design based on Models of Bruner and Gordon**

The Instructional Design based on the models of Bruner and Gordon termed as Integrated Instructional Model (IIM) is prepared by integrating Bruner’s concept attainment model and Gordon’s synectics model.

**Stages of the Design**

The development of the Design consists of three stages and is shown in Figure D.1.
The first stage of the study is started with the preparation of the instructional design based on two models, namely concept attainment model and synectics model. The purpose of this design (IIM) is to develop both conceptual understanding and creative problem-solving. An amalgamation of those models for the instructional design will impinge mainly the theories of Bruner and Gordon. So the essential phases of both models were included by maintaining their distinct identities in this new instructional design after having consulted the Guide and experts in the field. These stages are common and general for all subjects taught in schools, but they have to be expanded in accordance with the nature of the subject and technique to be used.

After the preparation of the design, topics from physics textbook of standard IX suitable for applying both concept attainment model and synectics model are selected and the topics are planned accordingly. The Instructional Design is implemented in order to attain the stipulated instructional goals.

**Description of the Design**

Concept attainment based on the theory of Bruner (1956) emphasizes the development of inductive reasoning, concept development and analysis, whereas synectics model based on the theory of Gordon (1961) aims at personal development and creative problem-solving skills.
Since this design aims at developing both concept learning and creative thinking abilities, the major theories adopted for the preparation of the Design are Bruner’s concept attainment (reception) and Gordon’s synectics (making the strange familiar) process. In some phases of the Design, other theories and principles like behaviourism, constructivism etc., are adopted. The major sequence of activities or tasks is developed accordingly and is named as phases. Figure D.2 shows the phases of the design and the theories and principles adopted for the development of these phases. An instructional model named as Integrated Instructional Model (IIM) is developed selecting the tasks/activities based on the schematic representation of phases of Instructional Design (Figure D.2). The phases of the design and major tasks of each phase are illustrated in Figure D.3.
<table>
<thead>
<tr>
<th>PHASES</th>
<th>PRINCIPLES AND THEORIES ADOPTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing Entry Behaviour</td>
<td>Several theories like behaviourism, meaningful verbal learning, and constructivism</td>
</tr>
<tr>
<td>Providing experiences to formulate hypotheses</td>
<td>Bruner’s theory of concept attainment (CAM)</td>
</tr>
<tr>
<td>Identification of the concept with the help of categorization</td>
<td>Bruner’s theory of concept attainment (CAM)</td>
</tr>
<tr>
<td>Assessing the attainment of Concept</td>
<td>Bruner’s theory of concept attainment (CAM)</td>
</tr>
<tr>
<td>Conceptualizing the concept by mapping with Direct Analogy</td>
<td>Gordon’s theory of Synectics Model (SM)</td>
</tr>
<tr>
<td>Generating new analogies</td>
<td>Gordon’s theory of Synectics Model (SM)</td>
</tr>
<tr>
<td>Reflection</td>
<td>Constructivism, CAM &amp; SM</td>
</tr>
</tbody>
</table>

*Figure D.2.* Schematic representation of the phases of the Instructional Design.
Figure D.3. Schematic representation of the phases and tasks of Integrated Instructional Model (IIM).
Phase 1: Testing the entry behavior

The first phase of the Design begins with assessing initial behavior which is required for the attainment of a new concept. Several theories like Ausubel’s meaningful verbal learning, Bloom’s mastery learning strategy, theories of behaviourism and constructivism etc., emphasize the importance of identifying entry behavior before providing new learning experiences. Prerequisites need to be acquired before the more advanced and higher-order skills can be learned. This is because all learning is hierarchical by nature. According to Zull (2002), learning is change in the brain. When we learn, neuronal networks of the brain go on changing. So, it is better to build new knowledge on the existing neuronal networks. This kind of proper bridging is the first step towards conceptualization of concepts.

Phase II: Providing experiences to formulate hypotheses

The second phase of the Design is presenting learning situations to formulate hypotheses. This will help to identify the essential attributes of the target concept. Bruner’s theory of concept attainment gives emphasis on identifying and testing hypotheses. Hence, this phase begins with the presentation of concrete learning experiences which clearly spell out the essential attributes of the concept to be taught. For instance, for attaining the concept “Force” teacher presents some activities that explain the relation between force and mass and the relation between force and acceleration. These learning events will help students to formulate hypotheses regarding the attributes of the concept ‘force’ by analyzing the given situations.

Phase III: Identifying the concept with the help of categorization

The major tasks involved in the phase are:

- Presenting the positive and negative instances of the concept
- Comparing the instances by the students
- Identifying the essential attributes of the concept
- Identifying the concept and naming
- Providing further learning situation (if necessary) to describe the nature of the concept

This phase of the Design is adopted from the model of Bruner, concept attainment. The concept attainment model allows students to categorize items based on analysis of the critical attributes. So this phase of the Design helps students to
categorize the instances, to analyze the instances, and to identify critical attributes of the concept. Hence, this phase provides guidelines to students in deriving abstract concepts inductively and using the skills of categorization.

Table D.1 presents positive and negative instances of the target concept, force.

Table D.1

<table>
<thead>
<tr>
<th>Positive instances</th>
<th>Negative instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A chair is pulled back</td>
<td>1. A chair is at rest</td>
</tr>
<tr>
<td>2. A moving ball is caught</td>
<td>2. A box is kept in the room.</td>
</tr>
<tr>
<td>3. Football player heads the ball</td>
<td>3. A player is standing near the goal post</td>
</tr>
<tr>
<td>to the goal post.</td>
<td></td>
</tr>
<tr>
<td>4. Pushing a box</td>
<td>4. A ball is moving continuously.</td>
</tr>
</tbody>
</table>

Here, the students are asked to compare the given positive and negative instances and to identify all critical attributes of the concept. Here, the students generate hypotheses and confirm the previously established hypotheses and attributes. Finally the students identify the attributes such as

- A push / pull
- A push / pull on a body produces motion
- A push / pull stops the motion
- A push / pull changes the direction of motion
- A push / pull changes the speed of the body.
- A push or pull which changes the state of rest or of uniform motion of a moving body in a straight line. As the push or pull increases, acceleration of the body increases.
- The amount of push or pull applied on the body increases as the mass increases.

After identifying the concept, teacher names the concept as “force”. Then, teacher further provides learning situation (if necessary) to clarify the concept. In the
case of the concept, force, students develop the formula $F = ma$. Students describe the concept and formulate the rule of the concept as

<table>
<thead>
<tr>
<th><strong>Force</strong> is that which changes or tends to change the state of rest or of uniform motion of a body in a straight line. A force can move a stationary body; it can change the speed of a moving body; it can change the direction of a moving body, it can change the shape or size of a body.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Force} = \text{mass} \times \text{acceleration}$</td>
</tr>
<tr>
<td><strong>Unit:</strong> - kg m/s$^2$ or Newton</td>
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</tbody>
</table>

**Phase IV: Assessing the attainment of concept**

Students are asked to give new examples of the concept. Here, teacher can also present additional unlabelled examples to test the attainment. This phase is adopted from the model of Bruner, reception-oriented concept attainment model.

**Phase V: Conceptualizing the concept by mapping with analogy**

This phase of the Design begins with the presentation of direct analogy of the concept. This is based on Gordon’s synectics model. In order to make the new concepts or ideas attained more meaningful, making the strange familiar (MSF) strategy of synectics model is selected for the preparation of the design. MSF strategy will help to increase the learners’ conceptualization of new concepts in physics.

Teacher presents direct analogy of the concept and asks to compare the analogy and the concept. Students identify the similarities and differences between the concept and analogy. The comparison need not be identical in all respects. It may be very close or distant.
For instance, the teacher suggests analogies for the concept ‘unbalanced external force’ are ‘lunar and solar tides’. Gravitational pull of the sun and moon causes rising and lowering of sea water.

When the collective gravitational pull of the moon and sun is strongest, the tides (rise of sea water level) occur. This is similar to the concept ‘unbalanced external force’. The similarities are given in the Table D.2.

Table D.2

*Similarities between the Analogue and the Target Concept*

<table>
<thead>
<tr>
<th>Spring tide</th>
<th>Unbalanced external force</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sea water</strong></td>
<td>Body</td>
</tr>
<tr>
<td><strong>Collective gravitational pull of moon &amp; sun on the earth’s water</strong></td>
<td>External forces acting on a body</td>
</tr>
<tr>
<td><strong>Rising of sea water due to the collective pull is strongest.</strong></td>
<td>Unbalanced external forces make the body move.</td>
</tr>
</tbody>
</table>

**Phase VI: Generating new analogies**

Teacher asks students to provide their own direct analogy and explore the similarities and differences. For instance, students suggest analogies for the concept are:

- Inertia is like human mind. The human mind has inertia. Our mind has a property to resist a change at every suggestion.
- When the weights on the common balance are balanced, the beam is balanced at its mid-point on a knife-edge. Otherwise, the pan which contains larger weight will go down. Similarly, in the case of unbalanced force, a body will move in the direction of larger force.

This task which is adopted from Gordon’s synectics model will help students to think about the concepts creatively.
Phase VII: Reflection

Many theories like constructivism, Gordon’s synectics and Bruner’s concept attainment highlight the importance of reflection. It is very essential to draw out the thinking patterns that are used by students in conceptualizing the concept.

The students describe the progression of their ideas during the process. They describe their thinking patterns that are used. They re-explore the concept attained on its own terms. Teacher explores the topic by asking thought-provoking questions and providing further explanations of the topic.

Conclusion:-

Science and technology are the driving forces of economic and social growth of our society and science education forms the backbone of all science and technology efforts in the country. Today it is being realized that the only way to improve the nation’s competitiveness is through better science education. Hence, science education at all levels should be strengthened by reforming and innovating teaching methodologies, curriculum patterns etc.

The Design based on the integration of theories of Bruner and Gordon, Integrated Instructional Model (IIM) helps learners to attain physics concepts inductively and then it allows them to think those attained concepts creatively. The appropriate use of apt examples and analogies of physics concepts helps them to develop both inductive and creative thinking and also helps to reduce the misconceptions in physics. Research also suggests that the use of a teaching strategy for the presentation of models, metaphors and analogies helps to integrate all parts of the brain. Hence, this design incorporates both the presentation of examples and analogies. This Design helps in developing critical abilities through the use of concept attainment strategy and creative thinking skills. The Integrated Instructional Model based on this Design (IIM) focuses on optimizing outcomes like attainment of concepts in physics and creative problem solving by blending the ‘right’ models of teaching to match the ‘right’ learning styles to transfer the ‘right’ skills to students in a ‘right’ way.
DEPARTMENT OF EDUCATION
UNIVERSITY OF KERALA

ACHIEVEMENT TEST OF CONCEPTS IN PHYSICS
(Draft form)

Standard IX
Duration: 45 mts
Marks: 40

General Instructions
1. Select the most suitable answer from the choices given (a, b, c, d) for each question and mark it by putting a ‘X’ mark against the letter given (a, b, c or d) in the box which you choose as the correct answer.
   For example, let the answer to a question be ‘c’. The method to be adopted for marking the answer is given below.
   
   a   b   c   d
   □   □   X   □

2. Each correct answer carries 1 mark.
3. Complete the test within the allotted time.

Now, start answering the questions.
1. Which of the following is an example of unbalanced force?
   a. A box on a table  
   b. A floating ship  
   c. An aeroplane taking off  
   d. A stationary weight hanging from a spring

2. Identify the direction of friction when a train moves towards south
   a. Towards south  
   b. Towards north  
   c. Towards west  
   d. Towards east

3. Observe the figure given below
   ![Image]
   Identify the effect of force acting in the game.
   a. Changes the speed of ball  
   b. Makes the moving ball stop  
   c. Changes the direction of the motion of ball  
   d. Changes the state of rest of ball

4. In which form is energy stored in our body?
   a. Mechanical energy  
   b. Potential energy  
   c. Kinetic energy  
   d. Chemical energy

5. When a body of mass increases, its kinetic energy
   a. Decreases  
   b. Increases  
   c. First increases then decreases  
   d. First decreases then increases

6. From the following, identify the device which can be used to transfer electrical energy to light and sound energy
   a. Microphone  
   b. Electrical energy  
   c. Solar cell  
   d. Television

7. An aeroplane’s velocity is doubled. Its momentum is
   a. Doubled  
   b. Halved  
   c. Quadrupled  
   d. not changed

8. Unit of force is
   a. newton-metre  
   b. kg m/s  
   c. newton/metre  
   d. kg m/s²
9. Work of an object is equal to
   a. F.s 
   b. F/s 
   c. F/s\(^2\) 
   d. F.s\(^2\)

10. Quantity of motion
    a. Kinetic energy 
    b. Work 
    c. Inertia 
    d. Momentum

11. Athletes usually run some distance before making a high jump. This is to take advantage of
    a. Inertia of rest 
    b. Inertia of motion 
    c. Momentum 
    d. Force of friction

12. From the following, identify the situation where work is done
    a. Going up in a lift 
    b. A table supporting a book 
    c. A person stands with a book in his head 
    d. A boy sitting in a chair

13. Unit of momentum is
    a. kg m/s\(^2\) 
    b. newton 
    c. kg m/s 
    d. none of these

14. When sudden brakes are applied by a driver of an auto rickshaw, passenger leans forward. This is because of
    a. Momentum 
    b. Force of friction 
    c. Inertia of rest 
    d. Inertia of motion

15. When a spring of a toy car of mass 500g is loosened, the velocity of the car is 10m/s. Kinetic energy of the car is
    a. 250J 
    b. 25J 
    c. 2.5J 
    d. 2500J

16. The total momentum of a rifle and bullet before firing is
    a. Zero 
    b. Non-zero 
    c. Infinity 
    d. Very large but not infinity

17. A toy gun is used to project a body of mass 20 kg to a height of 10m. Its potential energy is
    a. 2J 
    b. 0.2J 
    c. 1.96J 
    d. 0.196J

18. When the gas in an aerosol is squashed into a can it stores some form of energy. Identify the form of energy
19. When brakes are applied on a car the brake pads press against a moving part of the wheel, and the force of friction
   a. Decreases  
   b. Increases  
   a. No change  
   d. First increases then decreases  

20. The velocity of a body is V and its kinetic energy is ‘E’. When the velocity becomes 2V, the kinetic energy will be
   a. E/2  
   b. E  
   a. 4E  
   d. 2E  

21. Identify the unbalanced force from the following
   a. Pulling a rope with equal forces by both sides  
   b. Collision of a car with a scooter  
   c. Holding a suitcase  
   d. A cup on the table  

22. When the mass of a body is doubled, the potential energy will be
   a. Doubled  
   b. Halved  
   a. Quadrupled  
   d. Not changed  

23. The property of a body by which it tends to resist change in its state of rest is
   a. Inertia  
   b. Inertia of motion  
   c. Inertia of rest  
   d. Force  

24. The form of energy which is stored here is
   a. Gravitational potential energy  
   b. Strain potential energy  
   a. Kinetic energy  
   d. None of these  

25. It is easier to roll a wheel than to slide a box along the ground. This is due to
   a. Sliding friction < Rolling friction  
   b. Sliding friction > Rolling friction  
   c. Sliding friction = Rolling friction  
   d. None of these
26. Which of the following analogy(equivalent situation) is apt for the concept ‘inertia’
   a. Wrestling
   b. Spring tides
   c. Tug-of-war
   d. Fan continues to rotate for sometime even after it is switched off

27. When a body of mass 5 kg is lifted up by 2m, the work done is
   a. 9.8J       c. 98J
   b. 0.98J      d. 980J

28. To clean a carpet, we usually beat the carpet with a stick. This is because the dust particles have
   a. Force of friction  c. Inertia of motion
   b. Inertia of rest   d. Force of attraction

29. Body A has mass of 5 kg and body B has 10 kg. Which has more inertia?
   a. A               c. Both are equal
   b. B               d. Data insufficient

30. A stone of mass 1 kg is dropped from a height 10 m. What will be the kinetic energy of stone on reaching the ground?
   a. 98J            c. 9.8J
   b. 0.98J          d. 980J

31. Work is said to be done whenever
   a. Force is applied
   b. Energy is released
   c. Applied force moves an object in the direction of force
   d. None of these

32. You are given a circuit diagram with a battery, bulb, and switch. Identify the correct order of transformation of energy takes place here

   a. Chemical energy → light + heat
   b. Electrical energy → light + heat
c. Electrical energy ➔ chemical energy ➔ light + heat

d. Chemical energy ➔ electrical energy ➔ light + heat

33. Unit of work is
   a. newton-metre
   b. kg m/s
   c. newton/metre
   d. kg m/s²

34. Potential energy of a body on the ground is
   a. Maximum
   b. Zero
   c. Minimum
   d. Not zero

35. Identify the positive example of the concept ‘force’ from the following examples
   a. Rising of sun
   b. Sitting in a class
   c. Moving ball
   d. Pressing sponge in hand

36. The force which opposes the motion of the bodies
   a. Force of attraction
   b. Force of friction
   c. Gravitational force
   d. Inertia of motion

37. If the string is broken while drawing water from a well, we fall backward. This is due to
   a. Force of friction
   b. Gravitational pull
   c. Inertia
   d. None of these

38. The directions of momentum and velocity are
   a. Different
   b. Same
   c. Opposite
   d. Not related

39. Suppose a person walks horizontally to the earth’s surface with a weight in his hands. Here, the work done by the gravitational force on the body is
   a. Zero
   b. Minimum
   c. Maximum
   d. Data insufficient

40. A body placed on the ground having no momentum has
   a. Kinetic energy only
   b. Potential energy only
   c. Both kinetic energy and potential energy
   d. No energy
# RESPONSE SHEET

**ACHIEVEMENT TEST OF CONCEPTS IN PHYSICS**  
**(DRAFT FORM)**

Name of the student: ..........................

Name of the school: ..........................

<table>
<thead>
<tr>
<th>Qn. No.</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
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<tbody>
<tr>
<td>1.</td>
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<td>X</td>
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<td>2.</td>
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<td>9.</td>
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<td>11.</td>
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<td>16.</td>
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<td>18.</td>
<td>X</td>
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### APPENDIX D

**DIFFICULTY INDEX AND DISCRIMINATION POWER OF TEST ITEMS**

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*Note:* D. I – Difficulty Index; D. P - Discrimination Power.

*Item rejected*
DEPARTMENT OF EDUCATION  
UNIVERSITY OF KERALA  

ACHIEVEMENT TEST OF CONCEPTS IN PHYSICS  
(Final form)  

Standard IX  
Duration: 30 mts  
Marks : 25  

General Instructions  

1. Select the most suitable answer from the choices given (a, b, c, d) for each question and mark it by putting a ‘X’ mark against the letter given (a, b, c or d) in the box which you choose as the correct answer.  

For example, let the answer to a question be ‘c’. The method to be adopted for marking the answer is given below.  

```
  a  b  c  d  
```

   [ ] [ ] [X] [ ]  

2. Each correct answer carries 1 mark.  

3. Complete the test within the allotted time.  

Now, start answering the questions.
1. Athletes usually run some distance before making a high jump. This is to take advantage of
   a. Inertia of rest                 c. Momentum
   b. Inertia of motion              d. Force of friction

2. Which of the following is an example of unbalanced force?
   a. A box on a table              c. An aeroplane taking off
   b. A floating ship              d. A stationary weight hanging from a spring

3. Work is said to be done whenever
   a. Force is applied
   b. Energy is released
   c. Applied force moves an object in the direction of force
   d. None of these

4. To clean a carpet, we usually beat the carpet with a stick. This is because the dust particles have
   a. Force of friction              c. Inertia of motion
   b. Inertia of rest               d. Force of attraction

5. The form of energy which is stored here is
   a. Gravitational potential energy c. Kinetic energy
   b. Strain potential energy       d. None of these

6. The force which opposes the motion of the bodies
   a. Force of attraction           c. Gravitational force
   b. Force of friction            d. Inertia of motion

7. You are given a circuit diagram with a battery, bulb, and switch. Identify the correct order of transformation of energy takes place here
a. Chemical energy $\rightarrow$ light + heat  
b. Electrical energy $\rightarrow$ light + heat  
c. Electrical energy $\rightarrow$ chemical energy $\rightarrow$ light + heat  
d. Chemical energy $\rightarrow$ electrical energy $\rightarrow$ light + heat

8. An aeroplane’s velocity is doubled. Its momentum is  
   a. Doubled  
   b. Halved  
   c. Quadrupled  
   d. not changed

9. Which of the following analogy(equivalent situation) is apt for the concept ‘inertia’  
   a. Wrestling  
   b. Spring tides  
   c. Tug-of-war  
   d. Fan continues to rotate for sometime even after it is switched off

10. Quantity of motion  
    a. Kinetic energy  
    b. Work  
    c. Inertia  
    d. Momentum

11. Work of an object is equal to  
    a. F.s  
    b. F/s  
    c. F/s²  
    d. F. s²

12. The velocity of a body is $V$ and its kinetic energy is ‘$E$’. When the velocity becomes $2V$, the kinetic energy will be  
    a. $E/2$  
    b. $E$  
    c. $4E$  
    d. $2E$

13. Body A has mass of 5 kg and body B has 10 kg. Which has more inertia?  
    a. A  
    b. B  
    c. Both are equal  
    d. Data insufficient

14. Unit of force is  
    a. newton-metre  
    b. kg m/s  
    c. newton/metre  
    d. kg m/s²

15. When a spring of a toy car of mass 500g is loosened, the velocity of the car is 10m/s. Kinetic energy of the car is  
    a. 250J  
    b. 25J  
    c. 2.5J  
    d. 2500J
16. The total momentum of a rifle and bullet before firing is
   a. Zero          c. Infinity
   b. Non-zero      d. Very large but not infinity

17. When a body of mass 5 kg is lifted up by 2 m, the work done is
   a. 9.8 J         c. 98 J
   b. 0.98 J        d. 980 J

18. When a body of mass increases, its kinetic energy
   a. Decreases     c. First increases then decreases
   b. Increases     d. First decreases then increases

19. Suppose a person walks horizontally to the earth’s surface with a weight in his hands. Here, the work done by the gravitational force on the body is
   a. Zero          c. Maximum
   b. Minimum       d. Data insufficient

20. A body placed on the ground having no momentum has
   a. Kinetic energy only          c. Both kinetic energy and potential energy
   b. Potential energy only        d. No energy

21. Identify the direction of friction when a train moves towards south
   a. Towards south             c. Towards west
   b. Towards north             d. Towards east

22. A stone of mass 1 kg is dropped from a height 10 m. What will be the kinetic energy of stone on reaching the ground?
   a. 98 J         c. 9.8 J
   b. 0.98 J       d. 980 J

23. In which form is energy stored in our body?
   a. Mechanical energy        c. Kinetic energy
   b. Potential energy         d. Chemical energy

24. The property of a body by which it tends to resist change in its state of rest is
   a. Inertia     c. Inertia of rest
   b. Inertia of motion        d. Force

25. From the following, identify the situation where work is done
   a. Going up in a lift             c. A person stands with a book in his head
   b. A table supporting a book      d. A boy sitting in a chair
RESPONSE SHEET

ACHIEVEMENT TEST IN PHYSICS (FINAL FORM)

Name of the student: ...........................................
Name of the school: ...........................................

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# QUESTION-WISE ANALYSIS

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<th>Marks for each item</th>
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APPENDIX H

TEST OF CREATIVE THINKING
(Both Malayalam and English versions)
LESSON TRANSCRIPT: 1

TOPIC: FORCE

Objectives of the lesson:
The major objectives of the lesson are to attain the concept of force and to develop creative potential of students

Instructional goals:-
Students will be able to
1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept force
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Force’
6. Conceptualize the concept of force by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
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<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
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| **Entry behavior** | The lesson begins with assessing the essential previous knowledge for the learning of concept ‘force’. Students have attained the concepts of mass, velocity and acceleration earlier. | **Phase I**  
Testing the entry behaviour (several theories) |
| **Learning situations** | After assessing the entry behavior, the following situations are provided. Asks students to analyze the given situations and frame hypotheses to find out the major attributes of the concept. | **Phase II**  
Providing experiences (CAM) |
| **Learning situation 1** | 1. Presents the visuals describing different situations. In Figure 1. a, two girls are pushing a box of mass | }
40 kg. In Figure 1. b, instead of two girls, one boy is pushing the same box. What would happen if one boy pushed the box?

2. Figure 1. c shows the pulling of two stones of different masses by two boys.

Asks students to analyze these situations and formulate hypotheses regarding the relation between push exerted and velocity of the body and also the relation between the pull and mass of the body.

**Focusing questions:**

1. Compare the push exerted in situation 1. a & 1. b
2. In this case, which box moves faster?
3. What is the relation between push exerted and velocity of the box?

The given situations are observed and analyzed.

<table>
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<tr>
<th>Figure 1. a. Pushing a box</th>
<th>Figure 1. b. Pushing the box by one boy</th>
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Analyzing the situations

<table>
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<tr>
<th>Figure 1.c. Pulling of two different stones</th>
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Formulating hypotheses (CAM)

- When we push harder, the body moves faster
- Push or pull is directly proportional to velocity
- Push or pull is directly proportional to mass of the body
4. In Figure 1. c, relate the pull exerted by students and mass of the bodies

**Learning situation 2**
Asks students to observe the picture (Figure 1. d) carefully and to think about the relation between the push exerted on the cart and acceleration.

**Focusing questions:**
- If the pushing on the cart is the same and the mass increases, what change occurs in the acceleration of the loaded cart?
- If we push harder, what will happen to its acceleration?

**Learning situation 3**
Asks to identify more critical attributes involved in the concept regarding the nature of push or pull by

Focusing questions:
- If the pushing is the same, the acceleration of the empty cart is greater than the acceleration of the loaded cart.
- When we push harder, acceleration increases.
- Pushing is directly proportional to the mass.

**Figure 1. d. Pushing exerted on the cart in different situations**

Observe and analyze the situation.

Analyzing the situation

**Formulating hypotheses (CAM)**

**Phase III**
Categorizing and identifying the concept
comparing positive and negative instances. This will give the complete picture of the concept. **Positive instances**

- Pushing a cart
- Pulling a carrot
- Swinging
- Heading a ball
- Stopping a ball
- Moving car

**Negative instances**

- Books are kept on table
- Bench at rest
- A ball is moving continuously
- A sponge is kept in a box

**Focusing questions**

- Identify the critical attributes present in positive instances which are not present in

The given positive and negative instances are compared and categorized with the help of the focusing questions.

**Positive instances:**

- **Figure 1. e. Pushing a cart**

- **Figure 1. f. Pulling a carrot**

- **Figure 1. g. Swinging**

- **Figure 1. h. Heading a ball**

- **Figure 1. i. Stopping a ball**

- **Figure 1. j. Moving car**

Analyzing the situations (CAM) using the critical attributes (CAM)
negative instances.

- Identify the attribute which is necessary to move a body?
- What is the effect of push or pull in the given instances?

Asks students to identify the concept.

Names the concept as ‘Force’

<table>
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<th>Negative instances:--</th>
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<tr>
<td>Figure 1. k. Books are kept on table</td>
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<tr>
<td>Figure 1. l. Bench at rest</td>
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- A push or pull on a body produces motion of the body
- A push or pull can make a change the speed of the body
- A push or pull can change the direction of the moving body
- A push or pull can stop the motion of a body

A push or pull which changes the state of rest or of uniform motion of a moving body in a straight line. As the push or pull increases, acceleration of the body increases.

The amount of push or pull applied on the body increases as the mass increases.

Hypothesizing and identifying the critical attributes (CAM)

Identifying the concept

Naming the concept
Learning situation 4

Asks students to find out the relation between force, mass \((m)\) and acceleration \((a)\) with the help of the data given and restate the definition of the concept.

After analyzing the given data, the relation of force with mass and acceleration is found out.

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<th>a</th>
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<tr>
<td>(F_4 = 90)</td>
<td>(m_4 = 15)</td>
<td>(a_4 = 6)</td>
<td>(m_4 a_4 = ?)</td>
</tr>
<tr>
<td>(F)</td>
<td>(m)</td>
<td>(a)</td>
<td>(F = ?)</td>
</tr>
</tbody>
</table>

Describing the nature of the concept

**Force = mass \times acceleration**

*Force* is that which changes or tends to change the state of rest or of uniform motion of a body in a straight line.

A force can move a stationary body; it can change the speed of a moving body; it can change the direction of a moving body; it can change the shape or size of a body.
Learning situation 5
Generate new examples for describing the concept, Force

Learning situation 6
An analogy for the concept, ‘force’ is provided. Asks students to think the concept in a divergent way.
Water is continually being lost from leaves by transpiration. This loss of water in the leaves exerts a pull on the water in the xylem duct and draws more water into the leaf. It is just like drinking of water using straw. (Figure 1. m)
Transpiration pull of trees is greater than that of small plants.
Compare the pulling on the water and the relation between the number of

- Stretching a rubber band
- When we walk, we put a push on the ground
- Kicking a football
- A moving toy is pulled to stop

The given analogy is compared with the concept.

![Figure 1. m. Transpiration pull of plants](image)

The pulling exerted by the loss of water in leaves is similar to the force.
Due to the pull on the water, water moves from the root to the leaves.
When mass increases, we should apply more force to move a

Phase IV
Assessing the attainment of concept (CAM)

Phase V
Conceptualizing the concept by mapping with the concept (SM)
leaves and the rate of transpiration with the target concept force.

**Learning situation 7**

Suggests to cite new analogies and to describe those through mapping with the concept.

**Closure**

Asks students to describe the thought process and asks some thought provoking questions to assess learning.

Find out more life situations involving force.

---

<table>
<thead>
<tr>
<th>Phase VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generating new analogies and explaining the similarities and differences (SM)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflection</td>
</tr>
<tr>
<td>(constructivism, CAM &amp; SM)</td>
</tr>
</tbody>
</table>

body. Similarly, more leaves will result in a greater amount of water loss and an increased surface area for evaporation. This will increase the transpiration rate or will increase the pull.

New analogies are generated and described.

For example,

- Strength and existence of any political party depends on the support given by the people.
- Our consciousness is the product of wakefulness and the content.

Re-explore the topic by analyzing the thought process and finding answers to questions.

More situations describing the concept, force are identified.
LESSON TRANSCRIPT: 2

TOPIC: MOMENTUM

Objectives of the lesson:

The major objectives of the lesson are to attain the concept of momentum and to develop creative potential of students.

Instructional goals:-

Students will be able to:

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Momentum’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Momentum’
6. Conceptualize the concept of momentum by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th><strong>What teacher does</strong></th>
<th><strong>What students do</strong></th>
<th><strong>Phases &amp; Tasks</strong> (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| The lesson begins with assessing the essential prerequisites for the learning of the concept. Here, the concepts of force, mass and velocity have been taught earlier. Students have attained the concepts earlier. | | **Phase I**  
Testing the entry behaviour  
(Several theories) |
| **Learning situations** | The given situations are observed and analyzed. |  |
| After assessing the entry behavior, the following situations are provided. Asks to analyze the given situations and develop hypotheses to find out the major attributes of the concept. | | **Phase II**  
Providing experiences  
(CAM) |
| **Learning situation 1** |                     |                                    |
| 1. Hitting a cricket ball using a bat (Figure 2.a) | | |
| 2. Hit harder than in the previous case | | |
| 3. Hit a shot put ball using the same bat | | |
**Focusing questions:**

i. Compare the mass and velocity of the bodies given in three situations.

ii. Which is harder to stop?

iii. As the applied force increases what will happen to the velocity of the moving body?

iv. When the mass or the velocity of the body increases, what will happen to the nature of the force applied to stop the body?

**Learning situation 2**

Asks students to confirm the formulated hypotheses and to identify the critical attributes by comparing the given positive and negative instances of the concept.

**Positive instances:**

- A karate player strikes a pile of tiles or a

**Figure 2. a**

Formulate the hypotheses to identify major features of these situations.

- As the mass increases, velocity of the moving body decreases.
- When the exerted force increases, the body will move with greater velocity
- As the mass increases, it is harder to stop.
- The fast-moving object will require more force to stop it than a slow-moving object.

The two sets of instances are compared and the critical attributes of the concept are identified.

**Phase III**

Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations with the help of focusing questions and formulating hypotheses (CAM)
A slab of ice with his hand very fast (Figure L. 2 b).

- A fast moving cricket ball may hurt the batsman.
- Road accidents at high speed are very much worse than at lower speed.

**Negative instances:**
- A man is holding a pile of tiles.
- A ball is lying on the ground.
- A truck is parked near the shop.

**Focusing questions:**
- Why the karate player can strike a pile of tiles with hand very ‘fast’?
- Why is it harder to stop a fast moving ball?
- Identify the main features of the positive instances which are not present in negative instances.
- What kind of impact produced by a fast moving vehicle?

<table>
<thead>
<tr>
<th>Positive instances</th>
<th>Negative instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>- A karate player strikes a pile of tiles or a slab of ice with his hand very fast (Figure L. 2 b).</td>
<td></td>
</tr>
<tr>
<td>- A fast moving cricket ball may hurt the batsman.</td>
<td></td>
</tr>
<tr>
<td>- Road accidents at high speed are very much worse than at lower speed.</td>
<td></td>
</tr>
<tr>
<td>- A man is holding a pile of tiles.</td>
<td></td>
</tr>
<tr>
<td>- A ball is lying on the ground.</td>
<td></td>
</tr>
<tr>
<td>- A truck is parked near the shop.</td>
<td></td>
</tr>
</tbody>
</table>

Formulating hypotheses and identifying the critical attributes (CAM)
Whether a body possesses both mass and velocity when it is at rest?

Asks students to identify the concept on the basis of the attributes identified.

Names the concept as ‘Momentum’

**Learning situation 3**

Asks to find out the quantity of motion with the help of the data given and to describe the nature of the concept.

<table>
<thead>
<tr>
<th>Mass (m)</th>
<th>Velocity (v)</th>
<th>mass ( \times ) velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m_1 = 2 \text{ kg} )</td>
<td>( v_1 = 40 \text{ m/s} )</td>
<td>( m_1v_1 = ? )</td>
</tr>
<tr>
<td>( m_2 = 2 \text{ kg} )</td>
<td>( v_2 = 60 \text{ m/s} )</td>
<td>( m_2v_2 = ? )</td>
</tr>
<tr>
<td>( m_3 = 4 \text{ kg} )</td>
<td>( v_3 = 60 \text{ m/s} )</td>
<td>( m_3v_3 = ? )</td>
</tr>
<tr>
<td>( m_4 = 4 \text{ kg} )</td>
<td>( v_4 = 80 \text{ m/s} )</td>
<td>( m_4v_4 = ? )</td>
</tr>
</tbody>
</table>

- Greater force is needed for a body to move fast.
- Fast moving body exerts a greater impact.
- A massive object exerts a greater impact than a light object.
- A force is required to stop a moving body.
- A fast-moving massive object will require more force to stop it than a slow-moving light object.
- All moving bodies possess both mass and velocity.

<table>
<thead>
<tr>
<th>Mass (m)</th>
<th>Velocity (v)</th>
<th>mass ( \times ) velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m_1 = 2 \text{ kg} )</td>
<td>( v_1 = 40 \text{ m/s} )</td>
<td>( m_1v_1 = 80 \text{ kg m/s} )</td>
</tr>
<tr>
<td>( m_2 = 2 \text{ kg} )</td>
<td>( v_2 = 60 \text{ m/s} )</td>
<td>( m_2v_2 = 120 \text{ kg m/s} )</td>
</tr>
<tr>
<td>( m_3 = 4 \text{ kg} )</td>
<td>( v_3 = 60 \text{ m/s} )</td>
<td>( m_3v_3 = 240 \text{ kg m/s} )</td>
</tr>
<tr>
<td>( m_4 = 4 \text{ kg} )</td>
<td>( v_4 = 80 \text{ m/s} )</td>
<td>( m_4v_4 = 320 \text{ kg m/s} )</td>
</tr>
</tbody>
</table>

All moving bodies possess mass and velocity. As the mass of the body increases, the impact produced by the
Learning situation 4
Asks students to give more examples for the concept, momentum.

Learning situation 5
The ‘word’ momentum is a part of everyday life.
Suggests an analogy to compare with the concept ‘momentum’
In athletics, the support given by the body increases. Similarly, as the velocity increase, the impact produced also increases.

Momentum is directly proportional to mass and velocity.

**Momentum is a characteristic feature of objects in motion. It is the quantity of motion. It is the product of mass and velocity.**

\[
Momentum(p) = \text{mass } (m) \times \text{velocity} (v)
\]

*The unit of momentum is kgm/s.*

- A fast moving bullet causes more impact
- It is harder to stop a fast moving baseball
- The accident produced by a truck is greater than by a car

Compare the analogy with the concept.

The analogy is described by mapping it with the concept.

---

Phase IV
Assessing the attainment of concept (CAM)

Phase V
Conceptualizing the concept by mapping with analogy (SM)
coach inspires the team to gain a fast record.

Identify the similarities and differences (if any) between the analogy and the target concept ‘momentum’.

**Focusing questions:—**
- What impact is produced by the inspiration given by the coach?
- What effect is produced by the team which has got a lot of momentum?

**Learning situation 6**
Gives directions to cite more suitable analogies and to describe those through mapping with concept.

**Closure**
Asks students to describe the thought process followed. Asks questions to assess the learning.

<table>
<thead>
<tr>
<th>Analogy</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Fast record</td>
<td>+ Impact produced by the body</td>
</tr>
<tr>
<td>+ Move of the team</td>
<td>+ Body</td>
</tr>
<tr>
<td>+ Support given by the coach</td>
<td>+ Force applied on the body</td>
</tr>
<tr>
<td>+ Racing speed</td>
<td>+ Velocity of the body</td>
</tr>
<tr>
<td>+ Team coordination</td>
<td>+ Mass of the body</td>
</tr>
</tbody>
</table>

More analogies are generated and described. For example: In the realm of politics, it is hard to stop the politician, if he gains in public opinion polls. Here, he has gained ‘momentum’.

Describe the thought process.
Re-explore the topic.

**Phase VI**
Generating new analogies and explaining the similarities and differences (SM)

**Phase VII**
Reflection
(Constructivism, CAM & SM)
Objectives of the lesson:
The major objectives of the lesson are to attain the concept of unbalanced external force and to develop creative potential of students

Instructional goals:
Students will be able to
1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept 'Unbalanced force'
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept “Unbalanced external force”
6. Conceptualize the concept of Unbalanced force by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td></td>
<td><strong>Phase I</strong></td>
</tr>
<tr>
<td>The lesson begins with assessing the essential prerequisites for the learning of the concept. Here, the concepts of force, motion and displacement have been taught earlier. Students have attained the concepts earlier.</td>
<td></td>
<td>Testing the entry behaviour</td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td>(Several theories)</td>
</tr>
<tr>
<td>After assessing the entry behavior, the following situations are provided. Asks students to analyze the given situations and develop hypotheses to find out the major attributes of the concept.</td>
<td></td>
<td><strong>Phase II:</strong></td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td>Providing experiences (CAM)</td>
</tr>
<tr>
<td>Students are asked to observe the situations showing in the picture.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
carefully and analyze the situations to find out the hypotheses of the problem presented.

**Focusing questions:**
- In situation 1, what will be the net force?
- In which direction it has moved in the 2nd situation? Why?
- What will happen to the wishbone in the 3rd case?

**Learning situation 2**

Asks students to observe the instances carefully and identify all the critical attributes of the concept by comparing the given positive and negative forces acting on the wishbone.

Analyze the given situations and formulate the following hypotheses.
- An external force is required to move an object.
- The object will move in the direction of the larger force applied.
- When forces are not the same, the resultant force will not be zero.

The visuals presented are observed and hypotheses are formulated through discussion.

**Phase III**

Categorizing and identifying the concept using the critical attributes (CAM)
negative instances.

**Positive instances:**
- Pushing a car from one side
- Pulling a block from one side
- Two different forces act on a block
- Tug-of-war

**Negative instances:**
- Pushing a car from opposite sides with equal forces
- Pulling a block with equal forces
- Two equal forces acting on a block
- Tug-of-war with equal forces

**Focusing questions:**
- Identify the forces acting in each case.
- What will be the net force acting in each instance?

---

**Figure 3. a. Pushing a car**

**Figure 3. b. Pushing a car**

**Figure 3. c. Pulling a block**

**Figure 3. d. Two forces acting on a block**

**Figure 3. e. Tug-of-war**
➢ Identify the major features of cases given under positive instances.
➢ Identify the major features of negative instances.

**Negative instances:**

Figure 3. f. Pushing a car from opposite sides

<table>
<thead>
<tr>
<th>$F_1 = 100 \text{ N}$</th>
<th>$F_2 = 100 \text{ N}$</th>
</tr>
</thead>
</table>

Figure 3. g. Pulling a block with equal forces

Figure 3. h. Two forces acting on a block

100 N 100 N 100 N

Figure 3. i. Tug-of-war
<table>
<thead>
<tr>
<th><strong>Asks students to identify the concept.</strong></th>
<th><strong>All moving bodies are experienced by external forces.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The concept is named as ‘Unbalanced external forces’. When the forces are equal, what will be the concept?</strong></td>
<td><strong>The forces applied on the body are unequal and in opposite direction.</strong></td>
</tr>
<tr>
<td><strong>Learning situation 3</strong></td>
<td><strong>The resultant of these forces is not zero</strong></td>
</tr>
<tr>
<td></td>
<td><strong>The body moves in the direction of greater force.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>To move a stationary object, we have to exert a force greater than the opposing force acting on it.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>When the forces act on a body are not equal and in opposite direction, they produce a change in its state of rest or of uniform motion. The body will move in the direction of larger force.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Balanced forces.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Formulating hypotheses and identifying the critical attributes (CAM)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Identifying the concept</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Naming the concept (CAM)</strong></td>
</tr>
</tbody>
</table>
concept with the help of the situation given.

Asks to link two Newton meters as shown in Figure 4.j and to pull one end of the Newton meter is harder than the on the other. Repeat the experiment by pulling equally hard from both ends (Figure 4.k).

**Focusing questions:**
- What happens if the pull on one end of the Newton meter is harder than on the other?
- What will be the net force in two cases?
- Are the forces exerted same in both cases?

In the first situation, the forces acting on the hooks are no longer balanced. Both hooks will start to move to the left. So unbalanced forces lead to change in speed or direction. The net force will not be zero. But in the second situation, the resultant force of balanced force is zero.

<table>
<thead>
<tr>
<th>Figure 4. j. Unbalanced forces</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Unbalanced Forces" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Figure 4. k. Balanced forces</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Balanced Forces" /></td>
</tr>
</tbody>
</table>

Describing the nature of the concept
Learning situation 4
Presents some examples and asks to classify the concepts as balanced and unbalanced forces.

✓ A falling stone
✓ A floating ship
✓ Pushing a trolley
✓ Holding a suitcase
✓ A heavy box is kept on the ground

Asks to identify more examples of

The forces acting on the central hooks cancel each other out, because they are equal and opposite in direction. As the forces are balanced, the hooks do not move.

*If the resultant of all the forces acting on a body is zero, the forces are called balanced forces.*

*If the resultant of all the forces acting on a body is not zero, the forces are balanced forces. The unbalanced forces can produce motion in a stationary body or stop a moving body.*

The given examples are classified into balanced and unbalanced forces. New examples of the concept, unbalanced forces are given.

For example,

- Lifting a box
- An aero plane taking off
- Pulling a rope
- Pushing a heavy box

Phase IV
Assessing the attainment of concept (CAM)
the concept unbalanced forces.

**Learning situation 5**

Provides an analogy, spring tides (Figure 4.1) and asks to compare with the concept, unbalanced force with the help of the table given.

<table>
<thead>
<tr>
<th>Spring tide</th>
<th>Unbalanced force</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sea water</td>
<td>•</td>
</tr>
<tr>
<td>• Collective gravitational pull of moon and sun on the earth’s water.</td>
<td>•</td>
</tr>
<tr>
<td>• Rising of sea water due to the collective pull is strongest.</td>
<td>•</td>
</tr>
</tbody>
</table>

The visual showing spring tides is observed.

The elements of the concept are compared with the elements of the analogy. Similarities and differences (if any) are identified and the concept, unbalanced external forces are described in a more creative way.

![Image](image_url)

Figure 4.1. Spring tides at new moon and full moon days

<table>
<thead>
<tr>
<th>Spring tide</th>
<th>Unbalanced force</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sea water</td>
<td>• Body</td>
</tr>
<tr>
<td>• Collective gravitational pull of moon and sun on the earth’s water.</td>
<td>• External forces acting on a body</td>
</tr>
<tr>
<td>• Rising of sea water due to the collective pull is strongest.</td>
<td>• Unbalanced external forces make the body move.</td>
</tr>
</tbody>
</table>
Learning situation 6
Directions to suggest more analogies are given.
Asks students to explain the concept of unbalanced force.

Closure
Asks students to describe the thinking process followed for conceptualizing the concept.
Asks thought provoking questions to assess learning.

New analogies are explained. For example,
• Common balance used for measuring weights of things: - when the weights on the pans are balanced, the beam is balanced at its mid-point on a knife-edge. Otherwise, the pan which contains larger weight will go down.

The thought process is described and the topic is re-explored through answering the questions.

Phase VI
Generating new analogies and explaining the similarities and differences (SM)

Phase VII
Reflection (CAM, SM & constructivism)
Objectives of the lesson:

The major objectives of the lesson are to attain the concept of inertia and to develop creative potential of students

Instructional goals:

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Inertia’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Inertia’
6. Conceptualize the concept of inertia by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong>&lt;br&gt;Begins with assessment of the required previous knowledge which is essential for the concept, inertia. Students have attained the concepts of unbalanced external force, mass, velocity, state of rest, state of motion, and uniform motion earlier.&lt;br&gt;&lt;br&gt;<strong>Learning situations</strong>&lt;br&gt;After assessing the entry behaviour, the following situations are provided. Asks to formulate hypotheses for identifying the critical attributes of the concept to be attained.&lt;br&gt;&lt;br&gt;<strong>Learning situation 1</strong>&lt;br&gt;Asks to do the experiment (Figure 4. a &amp; Figure 4. b) and to analyze the following situations.</td>
<td></td>
<td><strong>Phase I</strong>&lt;br&gt;Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td></td>
<td>Activity is performed and the situations are observed.</td>
<td><strong>Phase II</strong>&lt;br&gt;Providing experiences (CAM)</td>
</tr>
</tbody>
</table>
1. Place a card on the tumbler and a heavy coin on the card. Strike the card suddenly. 
Narrates a situation of skidding vehicles on wet or icy roads (Figure 4. c).
Asks to discuss the situations with the help of focusing questions posed.

**Focusing questions:**
- In the first situation, where do you exert force?
- Before exerting force, what will be the state of the coin?
- What happens to the coin when the card flies off?
- In situation 2, identify the state of car before skidding.
- Why does it skid when the brakes are applied suddenly?

<table>
<thead>
<tr>
<th>Figure 4.a</th>
<th>Figure 4.b</th>
</tr>
</thead>
</table>

Analyzing the situations and formulating hypotheses (CAM)

<table>
<thead>
<tr>
<th>Figure 4.c</th>
</tr>
</thead>
</table>

- The card flies off due to the external force.
- The external unbalanced force can produce motion of the card.
- The coin falls into the tumbler because it continues the state of rest.
Learning situation 2
Presents some positive and negative instances of a concept.

Positive instances
1. Push a chair to keep it moving across the floor.
2. When a bus starts moving suddenly a standing passenger tends to fall backwards
3. To pluck mangoes we shake the branches of the tree (Figure 4.d).

Negative instances
1. When a fast moving bus is suddenly stopped, a standing passenger tends to fall forward (Figure 4.e).

- As the coin does not experience any external force, it continues its state of rest.
- The car continues its state of motion when the brakes are applied suddenly.

Analyze the situations given and observe the situations presented.

Phase III
Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)

Figure 4. d. Plucking mangoes (positive instance)
2. When we stop the pedaling of a fast moving bicycle, it will come to rest after travelling some distance (Figure 4.f).

3. A person jumping out of a moving train may fall forward

**Focusing questions**
- Identify the state of objects before applying the force.
- Identify the property they exhibit when an external force exerted on it
- Identify the major features of the positive instances
- Identify the major features of the negative instances

**Figure 4. e. Passengers in a fast moving bus (negative instance)**

**Figure 4. f. pedaling a bicycle (negative instance)**

**Hypothesizing and identifying the critical attributes (CAM)**
| Asks to identify the concept. | The attributes of positive instances are  
|                              | • External forces act on a body tend to produce motion.  
|                              | • A body continues in its state of rest until it is compelled by an external force to change its state of rest.  
|                              | • The tendency of a body to remain at rest.  
|                              | Critical attributes of the negative instances given are  
|                              | • External forces can stop a moving body.  
|                              | • A body continues in motion in straight line with a uniform speed unless is compelled by an external force to change its state of uniform motion  
|                              | • Tendency of a moving body to continue its state of uniform motion.  
|                              | • A body at rest or of uniform motion continues its position unless acted upon by an external force.  
|                              | • All bodies show a tendency to resist a change in its state of rest or of uniform motion.  
| Names the concept as ‘inertia’. | Name the concepts involved in the positive and negative instances as ‘inertia of rest’ and ‘inertia of...” |
Learning situation 3
Asks to discuss some examples of situation involving inertia in daily life.
- Cats and dogs dry their wet fur by shaking their body vigorously.
- Players run a certain distance before throwing a javelin or a cricket ball.
Asks to describe the nature of the concepts, inertia of rest and inertia of motion.

Learning situation 4
Asks students to give more examples of motion’ respectively.
- On shaking, the fur suddenly moves. The water particles have a tendency to remain at rest due to their inertia. Thus the water particles get separated from their fur.
- This is to take advantage of inertia of motion. When they run, they can make a throw to a maximum distance.

\[ \text{Inertia of rest is the incapability of a body to change itself its state of rest.} \]
\[ \text{Inertia of motion is the incapability of a body to change itself its state of uniform motion along a straight line.} \]
\[ \text{Therefore, inertia is that property of a body due to which it resists a change in its state of rest or of uniform motion.} \]
- Athletes run a certain distance before taking a long jump.
- The dust particles in a carpet fall off when it is beaten.

Analyzing the situations
Describing the nature of the concepts

<table>
<thead>
<tr>
<th>Phase IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessing the attainment of concept (CAM)</td>
</tr>
</tbody>
</table>

| Lesson Transcripts 1 |
“Inertia”.

**Learning situation 5**

Gives an analogy of acoustic inertia to compare with the concept of inertia and asks to describe the concept, inertia. 
Provides a flute and asks to play the flute. 
Gives directions to observe the situation and to compare with inertia. 

**Learning situation 6**

Gives directions to suggest more analogies to explain the concept of inertia. 

**Closure**

Asks to describe the thought process and asks some thought provoking questions to assess learning. 
Why do rabbits run in a zig-zag manner to escape from dogs? 
Find out more life situations involving inertia. 

---

with a stick. 

Play the flute. After discussion, present the similarities of this with the concept. 

When we play a flute, a force tends to vibrate the molecules and thus, to produce music. But when it stops, the moving particles show a property to resist its state. So vibrations of air molecules in flute or organ pipes take time to diminish after the forces causing them to stop. 

Suggest some analogies such as: 
- Blades of an electric fan continue to rotate for sometime after current is switched off. 
- Inertia means opposition to change. It is similar to human mind. The human mind has inertia. Our mind has a property to resist a change at every suggestion. 

Describe the thought process. Find answers to questions are found out and conclude that heavier bodies possess greater inertia. 

---

**Phase V**

Conceptualizing the concept by mapping with the concept (SM) 

---

**Phase VI**

Generating new analogies and explaining the similarities and differences (SM) 

---

**Phase VII**

Reflection (constructivism, CAM & SM)
LESSON TRANSCRIPT: 5

TOPIC: FRICTIONAL FORCE

Objectives of the lesson:

The major objectives of the lesson are to attain the concept of frictional force and to develop creative potential of students.

Instructional goals:

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept frictional force
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Frictional force’
6. Conceptualize the concept of friction by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
**Lesson Transcripts**

<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td></td>
<td><strong>Phase I</strong></td>
</tr>
<tr>
<td>The lesson begins with assessing the essential previous knowledge for the learning of the concept, ‘friction’. Students have attained the concepts of force, mass, balanced &amp; unbalanced forces, acceleration and motion earlier.</td>
<td></td>
<td>Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td><strong>Phase II</strong></td>
</tr>
<tr>
<td>After assessing the entry behaviour, the following situations are provided. Asks students to analyze the given situations and frame hypotheses to find out the critical attributes of the concept.</td>
<td></td>
<td>Providing experiences (CAM)</td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asks students to roll a ball on the floor</td>
<td>After performing the activity, the difference occurs in two situations is noted.</td>
<td></td>
</tr>
</tbody>
</table>
of the classroom. What will happen? Spread a little oil on the floor. Roll the ball. What is the difference between the two situations?

Think about the reason behind this difference.

**Learning situation 2**

Asks students to observe the given positive and negative instances and to identify all the critical attributes of the concept.

**Positive instances**
- Walking
- Holding objects
- Writing with a pencil on a paper
- Rubbing your hands together to

![Figure 5. a. A ball is rolling on the floor](image)

When we roll a ball on the floor, it stops after sometime, even though we are not applying any force from the opposite direction. But when we spread oil on the floor, it keeps moving on the oiled surface. But the difference is the ball stops shortly after it starts rolling on the plain floor (without oil on it). Because the opposing force becomes less in the second situation

**Positive instances**

![Figure 5. b. walking](image)

![Figure 5. b. Holding objects](image)

Analyzing the situation.

**Phase III**

Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)
create warmth

- Bicycle brake helps to slow down

**Negative instances**
- An astronaut waking in space
- Satellites in space

**Focusing questions:**
- Identify the forces acting in each case.
- Why is it very difficult to hold smooth and polished objects?
- An ice skater moves easily on ice. Why?
- When we kick a ball, it moves some distance. But it stops after sometime. Why?
- What will happen when we kick a ball in space? Why?

**Figure 5. d. Writing**

**Figure 5. e. Forces acting on the bicycle**

**Negative instances:**

**Figure 5. f. Space walking**

**Figure 5. g. Satellites moving in space**
| Asks students to identify the concept | ✓ When we walk, we push forward by pushing backwards on the ground.  
✓ The smooth or oily surface reduces the opposing force.  
✓ Ice skater experiences minimum opposing force.  
✓ As the ground exerts an opposing force on the ball, the rolling ball stops after sometime.  
✓ Due to the absence of air resistance, the ball never experiences any opposing force.  
  * Whenever an object moves over another surface or body, it experiences an opposing force.  
  * The force exerted by the body and the force exerted by the surface are in opposite direction.  
A force that resists motion between two objects those are in contact with each other. Smoother surfaces exhibit less opposing force, while rougher surfaces exhibit more opposing force. |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>The concept is named as ‘frictional force’.</td>
<td>Hypothesizing and identifying the attributes (CAM)</td>
</tr>
<tr>
<td></td>
<td>Identifying the concept</td>
</tr>
<tr>
<td></td>
<td>Naming the concept (CAM)</td>
</tr>
</tbody>
</table>
Learning situation 3
Asks students to find out the uses of friction in our life. Describe the concept of friction.

**Focusing questions**
- How do automobile brakes work?
- An eraser can rub off the matter written in pencil. How?
- Why do you fix rubber or plastic caps at the leg tips of the furniture?

Learning situation 4
Asks students to cite more examples of friction and to identify the surfaces between which friction acts in each example.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>When we apply brakes, the frictional force opposes the motion and finally stops the vehicle.</td>
</tr>
<tr>
<td></td>
<td>Eraser uses friction to rub off the matter.</td>
</tr>
<tr>
<td></td>
<td>Rubber offers very high friction. This will help the furniture remain in their respective places.</td>
</tr>
<tr>
<td></td>
<td>Whenever a body moves over another body a force comes into play between the surfaces in contact and parallel to the surfaces. This force, friction tries to oppose the motion of one body over the other.</td>
</tr>
<tr>
<td></td>
<td>A match sticks lights up due to friction.</td>
</tr>
<tr>
<td></td>
<td>Friction allows us to draw diagrams on paper.</td>
</tr>
<tr>
<td></td>
<td>Friction helps to brush our teeth.</td>
</tr>
<tr>
<td></td>
<td>Frictional force offered by air helps the parachute to have a slow landing.</td>
</tr>
</tbody>
</table>

Describing the nature of the concept

Phase IV
Assessing the attainment of concept (CAM)
Learning situation 6

Analogies are provided. Asks students to compare these with frictional phenomena.

Asks students to join together the teeth of two combs and to move one over the other (Figure 5. i). What do you observe? Repeat this with tooth brushes.

Compare these analogies with the surfaces in contact and frictional phenomena.

- Pyramids or castles can be built of cards because of friction (Figure 5. h).

![Figure 5. h](image)

Observe the situations and compare these with the surfaces in contact and frictional phenomena.

In frictional phenomena, the frictional force acts between two surfaces. When one moves over another it tries to oppose the motion of the surface. Friction is more in rough surfaces where as smooth surface exhibits less friction.

Similarly in the case of combs, it experiences more opposing force than in the case of brushes. But both (Figure 5. i) looks like the two surfaces in contact (Figure 5. j).

**Phase V**

Conceptualizing the concept by mapping with the concept (SM)
Learning situation 7
Asks students to generate more analogies to explain the concept of friction.

More analogies are given. For example,

- Life can be compared with friction. If we are having more trouble in planning anything, we feel uncomfortable. If we reduce this trouble, the

Phase VI
Generating new analogies and explaining the similarities and differences (SM)
Closure
Asks students to describe the thinking process and asks some thought provoking questions to assess learning. Find out more uses of friction from life situations and identify the situations showing disadvantages of friction. How can reduce friction in those situations.

| planning goes on smoothly.  
| • Oil flows more freely than honey. The resistance to flow is high in the case of honey.  
| • Resistance to the flow of current is like friction.  

Explain the thinking process used for conceptualizing the concept.
More uses and disadvantages of friction are identified and described.

Phase VII
Reflection (constructivism, CAM & SM)
LESSON TRANSCRIPT: 6

TOPIC: SLIDING AND ROLLING FRICTION

Objectives of the lesson:

The major objectives of the lesson are to attain the concept of sliding and rolling friction and to develop creative potential of students.

Instructional goals:

Students will be able to:

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘sliding and rolling friction’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘sliding and rolling friction’
6. Conceptualize the concept of sliding and rolling friction by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
### Lesson Transcripts

<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
</table>
| **Entry behaviour** | The lesson begins with assessing the essential previous knowledge for the concept, ‘sliding and rolling friction’. Students have attained the concept of frictional force earlier. | **Phase I**  
Testing the entry behaviour (several theories) |
| **Learning situations** | After assessing the entry behaviour, the following situations are provided. Asks students to analyze the given situations and formulate hypotheses to find out the critical attributes of the concept. |  |
| **Learning situation 1** | Asks students to place a block on the table and to push it lightly with hand (Figure 6. a). Now push it | **Phase II**  
Providing experiences (CAM) |
| | The activity is performed and the difference between the two situations experienced is noted. | |
harder. What do you experience?

Now, place the block on rollers and asks students to push it (Figure 6. c).

Identify the difference between the force exerted in two cases.

**Focusing questions:**
- Does the block move when you push the block lightly? Why?
- What will happen when you push it harder? Why?

### Learning situation 2
Asks students to observe the given positive and negative instances and to identify all the critical attributes of the concepts

<table>
<thead>
<tr>
<th>Figure 6. a</th>
<th>Figure 6. b</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
</tbody>
</table>

- The block doesn’t move when we push it lightly.
- The block doesn’t move because the applied force and the frictional force are balanced.
- The frictional force and applied force are not balanced
- The block moves when the applied force exceeds the force of friction.
- When we place the block on rollers, the force of friction becomes less.
- When we push lightly, the blocks moves easily because of the low frictional force.

The situations are analyzed and the attributes of the instances are identified.

### Phase III
Categorizing and identifying the concept using the critical attributes (CAM)
given in the instances.

- Friction exists between block and the floor when the block slides over the floor (Figure 6. c).
- When a glass block slides over the table top, the force of friction exists between the two surfaces (Figure 6. d).
- Frictional force exists between book and top of the table when we a book slides over the table top (Figure 6. e).

**Negative instances**

- When a tyre of wheel is in contact with the road, frictional force exists between the tyre and the surface of road (Figure 6. f).
- The wheels on the bottom of the
roller skates help to glide across surfaces (Figure 6. g).

- It is easy to push a box when it is placed over the rollers (Figure 6. h).
- The glass box moves easily when is placed over the rollers (Figure 6. i).

**Focusing questions:**

- Identify the major attributes of the positive instances.
- Identify the attributes of the negative instances.

- Force of friction exists between when one surface slides over another surface.
- Force of friction exists between when one surface rolls over another surface.
- A body moves easily when it rolls over a surface.
Asks students to identify the concept which involves in the positive instances.

Names the concept as ‘sliding friction’.

Asks to identify and name the concept involved in negative instances.

Describe the nature of the concept.

| Learning situation 3 |  |
|----------------------|--|---|
| Give more examples for sliding friction and rolling friction. |  |  |

- Force of friction becomes less when a body rolls over a surface.

A minimum force is required to make a body to slide over a surface.

Force of friction exists between when one body rolls over a surface. This force of friction is ‘rolling friction’.

**Sliding friction acts between two surfaces in contact that are sliding against one another whereas rolling friction occurs when a round object rolls on a flat surface. Rolling friction is less than sliding friction.**

Sliding friction exists in

- Skiing through the mountains
- Sliding windows

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Identifying the concept</td>
<td></td>
</tr>
<tr>
<td>Naming the concept (CAM)</td>
<td></td>
</tr>
<tr>
<td>Describing the nature of the concept</td>
<td></td>
</tr>
<tr>
<td><strong>Phase IV</strong></td>
<td>Assessing the attainment of concept (CAM)</td>
</tr>
</tbody>
</table>
Learning situation 4

Analogy for explaining the concepts of sliding and rolling friction is presented.

Conflicts occur between persons having dissimilar ideas or interests are similar to sliding and rolling friction. Explain the similarities and differences between the analogy and the concept.

- Playground slides
- Rolling friction exists in
- Rollers attached to the sliding doors or gates helps to move along a surface
- Sliding gates
- Road rollers

When we slide a box over a surface, frictional force between the box and the surface. This force opposes the motion of the box. If we place the box on rollers, the box moves easily. Frictional force between the surface of the rollers and the surface of the floor is less than sliding friction. So the rollers help to move easily over a surface. Similarly, conflict or clash occurs between persons having dissimilar ideas. Conflicts are similar to sliding friction. To overcome these situations we adopt many measures like respect other’s views or ideas to reduce the conflict. This acts like a roller or any round object in reducing friction.

Phase V

Conceptualizing the concept by mapping with the concept (SM)
**Learning situation 5**  
Give more analogies for explaining sliding friction.

**Closure**  
Asks students to describe the thinking process and asks some thought provoking questions to assess learning.

<table>
<thead>
<tr>
<th>Phase VI</th>
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</thead>
<tbody>
<tr>
<td>Generating new analogies and explaining the similarities and differences (SM)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflection (constructivism, CAM &amp; SM)</td>
</tr>
</tbody>
</table>

New analogies are generated. For example,
- Movement of persons in foot path of a crowded road. This situation opposes the motion of persons.

The thinking process used for conceptualizing the concept is explained and answers to the questions are described.
LESSON TRANSCRIPT: 7

TOPIC: WORK

Objectives of the lesson:

The major objectives of the lesson are to attain the concept of work and to develop creative potential of students.

Instructional goals:

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Work’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Work’
6. Conceptualize the concept of work by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
What teacher does | What students do | Phases & Tasks (Principles used)
---|---|---
**Entry behaviour**
The lesson begins with assessing the essential previous knowledge for the learning of concept, ‘work’. Students have attained the concepts like force, displacement and motion earlier.

**Learning situations**
After assessing the entry behaviour, the following situations are provided. Asks students to analyze the given situations and formulate hypotheses to find out the critical attributes of the concept.

**Learning situation 1**
Ask a student to stand with a bundle of books on his head. After that, ask him to walk to a certain distance. The situations are observed and analyzed.

**Phase I**
Testing the entry behaviour (several theories)

**Phase II**
Providing experiences (CAM)
distance with the bundle. Then, ask him to climb up on the bunch with the books on his head. Asks to identify the force exerted on the books and the direction of displacement of the books.

**Focusing questions:**

- In which direction force is applied on the books, when a boy is standing with a bundle of books on his head? Is there any displacement of books occurs?
- When a boy is walking to a certain distance with the bundle of books, what will be the direction of displacement of books and the upward force.
- When he climbs up on the bench with the books, what will be the direction of displacement and the

---

<table>
<thead>
<tr>
<th><strong>Books</strong></th>
<th><strong>No displacement of books</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Force</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Analyzing the situations*

<table>
<thead>
<tr>
<th><strong>Books</strong></th>
<th><strong>Displacement</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Force</strong></td>
<td></td>
</tr>
</tbody>
</table>
upward direction of the force?  
- Identify the situation where the direction of displacement is in the direction of the point of application of force.

**Learning situation 2**
Asks students to identify the critical attributes of the concept by comparing the positive and negative instances of the concept.

*Positive instances*
- A box moves in the direction of pulling (Figure 7. a).
- A wheelbarrow is moving in the direction of pulling (Figure 7. b).
- A ball moves in the direction of kicking (Figure 7. c).
- Pushing a heavy trolley for 10m

- When he climbs up on the bench, the direction of the displacement is in the direction of the upward direction.

![Books](image1)

![Displacement](image2)

**Positive instances**

- *When the book is raised to a height, the book is displaced in the direction of the point of application.*

*Figure 7. a*  
*Figure 7. b*  
*Figure 7. c*  
*Figure 7. d*

**Phase III**
Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations
A rocket accelerates through space (figure 7. e).

Negative instances

- Pushing against a wall (Figure 7. f).
- Holding a chair and walking around the classroom (Figure 7. g).
- A waiter carries a tray full of meals above his head by one arm straight across the room at constant speed (Figure 7. h).

Figure 7. e

**Negative instances**

Figure 7. f

Figure 7. g

Hypothesizing and identifying the critical attributes (CAM)
Names the concept as ‘Work’

**Learning situation 4**

Asks students to analyze the data and find out the work done in each case.

Work done in each case is found out by analyzing the data.

---

*Figure 7. h*

- Force produces motion.
- The body moves in the direction of the applied force.
- The direction of displacement of the body and the direction of applied force are same.
Focusing questions:

- How can we determine the work done?
- Describe the concept Work in physics.
- What is the unit of work done?

Work done in moving a body is equal to the product of force exerted on the body and the distance moved by the body in the direction of force.

If the point of application of force moves in the direction of force applied on it we say a work is done and if there is no movement of the point of application of force, no work is done.
**Learning situation 5**
Asks students to cite more examples of work.

**Learning situation 6**
Analogy of reputation of school is provided to conceptualize the concept of work.

<table>
<thead>
<tr>
<th>Analogy</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper instruction &amp; administration</td>
<td>Force applied</td>
</tr>
<tr>
<td>Result obtained in public exam</td>
<td>Distance moved</td>
</tr>
<tr>
<td>Reputation of school</td>
<td>Work done</td>
</tr>
</tbody>
</table>

**Work** = \( \text{Force} \times \text{Distance moved in the direction of force} \)

**Unit**: Nm or joule

- A teacher pulling a boy along on a rope.
- Cutting a piece of cheese
- Striking a match
- Going up in a lift

The given analogy is compared with the concept and described.

**Phase IV**
Assessing the attainment of concept (CAM)

**Phase V**
Conceptualizing the concept by mapping with the concept (SM)
Asks to identify the similar elements of the concept against each element of analogy.

**Learning situation 7**
Asks to give more analogies and to describe those.

**Closure**
Asks students to describe the thinking process and asks some thought provoking questions to assess learning.

New analogies are generated and described.
- Development of a country depends on the governing body of the country.
- Character of an individual depends on his home environment.

The thinking process used for conceptualizing the concept is explained and answers to the questions are described.

**Phase VI**
Generating new analogies and explaining the similarities and differences (SM)

**Phase VII**
Reflection (constructivism, CAM & SM)
Objectives of the lesson:

The major objectives of the lesson are to attain the concept of energy and to develop creative potential of students.

Instructional goals:

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘energy’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘energy’
6. Conceptualize the concept of energy by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills

LESSON TRANSCRIPT: 8

TOPIC: ENERGY
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td>What students do</td>
<td><strong>Phase I</strong> Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td>The lesson begins with assessing the essential previous knowledge for the learning of concept, ‘energy’. Students have attained the concept of work, mass and velocity earlier.</td>
<td>The given data are analyzed and the works done by two persons are calculated.</td>
<td><strong>Phase II</strong> Providing experiences (CAM)</td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After assessing the entry behaviour, the following situations are provided. Asks students to analyze the given situations and formulate hypotheses to find out the critical attributes of the concept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asks students to calculate the work done by two persons.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson Transcripts

<table>
<thead>
<tr>
<th>Person</th>
<th>Force</th>
<th>Distance</th>
<th>Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8N</td>
<td>2m</td>
<td>16J</td>
</tr>
<tr>
<td>B</td>
<td>7N</td>
<td>3m</td>
<td>21J</td>
</tr>
</tbody>
</table>

What will be the work done by two persons?
Identify the person who has done more work.
Are both having the ability to do work?
Is the ability to do work the same?

**Learning situation 2**

Asks students to identify the attributes of the concept.

**Positive instances**

- Wind has the capacity to rotate the blades of wind turbines (Figure 8.a).
- Steam is used for generating current, producing chemicals, for oil refining etc. (Figure 8.b).

The works done by two persons are not the same.
The person B has done more work than the person A.
Both of them are having the ability to do work. But the amount of energy used in doing the work is different.

The given instances are compared and the attributes are identified.

**Positive instances**

![Figure 8. a](image1)

![Figure 8. b](image2)

Analyzing the situations and hypothesizing

**Phase III**

Categorizing and identifying the concept using the critical attributes (CAM)
• Moving water has the capacity to turn turbines (Figure 8. c).

**Negative instances**

• Listening music (Figure 8. d)
• A ball kept on the floor (Figure 8. e).
• Observing flowers (Figure 8. f).
• A sponge on the ground (Figure 8. g).

**Focusing questions:**

• Identify the situations where work is done.
• Identify the situations which are having the capacity to do work.
• What are the common attributes of the concept?

Analyzing the situations identifying the critical attributes and the concept (CAM)
Names the concept as ‘energy’.

**Learning situation 3**
Asks students to identify the various forms of energy from our environment. Asks to describe the details.

The common attributes of the positive instances are

- Force is required to work
- The ability to do work

- Solar energy: - To burn things, to prepare food, to generate current, light etc.
- Wind energy: - to generate current, to blow off things
- Heat energy; - to generate current, to cook things, to do chemical reactions etc.
- Fuel energy
- Nuclear energy
- Mechanical energy

**The capacity to do work is called ‘energy’**

When something or someone does work, the amount of work done is equal to the amount of energy used in doing the work. Work and energy are so closely related that they have the same unit, the **joule**.

- A fast moving ball is hitting at the cricket stump.

**Phase IV**
Assessing the attainment of concept (CAM)
# Learning situation 5

Provides an analogy of money to explain the concept of energy.

<table>
<thead>
<tr>
<th>Analogy</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paying cash</td>
<td>Force applied</td>
</tr>
<tr>
<td>Getting goods</td>
<td>Moved in the direction or change caused</td>
</tr>
<tr>
<td>Spent money for different purpose</td>
<td>Energy is having different forms</td>
</tr>
<tr>
<td>Managing money properly</td>
<td>Efficient utilization of energy</td>
</tr>
</tbody>
</table>

Asks students to find out similarities and differences (if any) of the analogy, money and the concept, energy.

- A hammer falling on the nail on a plank.
- A boy jumping down from a height.
- A coconut is falling from coconut tree.

**Comparisons are made and described.**

<table>
<thead>
<tr>
<th>Analogy (Money)</th>
<th>Concept (Energy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paying cash</td>
<td>Force applied</td>
</tr>
<tr>
<td>Getting goods</td>
<td>Moved in the direction or change caused</td>
</tr>
<tr>
<td>Spent money for different purpose</td>
<td>Energy is having different forms</td>
</tr>
<tr>
<td>Managing money properly</td>
<td>Efficient utilization of energy</td>
</tr>
</tbody>
</table>

Energy is like money. When we pay cash, we get things which we want. Similarly whenever we apply force,
**Learning situation 6**
Asks to give more analogies to explain the concept.

**Closure**
Asks students to describe the thinking process and asks some thought provoking questions to assess learning.

| the body moves in the direction of force or makes changes in its form. Energy has different forms. Similarly we use money for different purposes. Efficient and proper management of money helps to preserve our economic system. In the same way efficient utilization of energy preserves our environment. |
| Present new analogies for the concept. Energy is like power of position, occupation etc. |
| The thinking process used for conceptualizing the concept is explained and answers to the questions are described. |

**Phase VI**
Generating new analogies and explaining the similarities and differences (SM)

**Phase VII**
Reflection (constructivism, CAM & SM)
Objectives of the lesson:

The major objectives of the lesson are to attain the concept of kinetic energy and to develop creative potential of students.

Instructional goals:

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Kinetic energy’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Kinetic energy’
6. Conceptualize the concept of inertia by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong>&lt;br&gt; Begins with assessment of the essential previous knowledge for the learning of concept, kinetic energy. Students have attained the concepts of energy, work, mass, and velocity earlier.</td>
<td></td>
<td><strong>Phase I</strong>&lt;br&gt;Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td><strong>Learning situations</strong>&lt;br&gt; After assessing the entry behaviour, the following situations are provided. Asks to formulate hypotheses for identifying the critical attributes of the concept to be attained.&lt;br&gt;&lt;br&gt;<strong>Learning situation 1</strong>&lt;br&gt;Asks students to observe the visuals are observed and formulated hypotheses with the help of focusing questions.</td>
<td></td>
<td><strong>Phase II</strong>&lt;br&gt;Providing experiences (CAM)</td>
</tr>
</tbody>
</table>
situations and to identify the attributes.

1. Flowing water on a water wheel (Figure 9.a).
2. A fast moving ball hits the wicket (Figure 9.b).

**Focusing questions:**

**Situation 1**
- What does happen when water flows on the wheel?
- How did the wheel get the ability to turn?
- How did the flowing water get the ability to turn the wheel?

**Situation 2**
- What does happen when the ball hits the wicket?
- How did the ball get the

- A flowing water has the ability to do work
- A moving ball has the ability to do work.

Analyzing the situations and formulating hypotheses (CAM)
ability to push back the stumps?

**Learning situation 2**

Asks students to observe and compare the positive and negative instances of the concept.

**Positive instances**

- A moving hammer drives a nail into wood (Figure 9. c).
- Moving wind turns the blades of the turbine (Figure 9. d).
- A running car (Figure 9. e).

**Negative instances**

- Toys placed on the table (Figure 9. f).
- A stretching rubber band

The following instances are analyzed and the critical attributes of the concept are identified.

<table>
<thead>
<tr>
<th>Positive instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 9. c</td>
</tr>
<tr>
<td>Figure 9. d</td>
</tr>
<tr>
<td>Figure 9. e</td>
</tr>
</tbody>
</table>

**Phase III**

Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)
has the ability to do work (Figure 9. g)

- A ball placed at the top of the steps (Figure 9. h).

Asks to identify the concept.

**Negative instances**

- Possess the ability to do work.
- Moving bodies
- Bodies possess energy due to its motion.

All moving bodies possess energy due to its motion.

Hypothesizing and identifying the critical attributes (CAM)
Names the concept as ‘Kinetic energy’.

**Learning situation 3**

Asks students to keep a smooth plank of wood 1m long inclined. Keep a rubber ball on the ground, a little in front of the plank and mark the position. Roll down an empty tin from the top of the plank. The tin will hit the ball causing it to move forward. Measure and note the distance the ball moved. Fill the tin with sand and repeat the experiment.

Roll down the tin filled with sand and empty tin from the same height of the inclined plane and note down the

The activity is performed and the observations are noted.

- When the tin rolls down from different heights, the tin possess kinetic energy and the amount of energy differs.
- When the tin placed at greater height, it acquires more velocity.
- As the velocity increases, kinetic energy increases.
- The tin filled with sand acquires more energy.
- As the mass increases, kinetic energy also increases.

**Identifying the concept (CAM)**

**Naming the concept (CAM)**

**Analyzing the situations and formulating hypotheses**
distance moved by the ball.

**Focusing questions:**
- On which situation did the ball move to a greater distance?
- When the tin rolls down from different heights, what happens to the ball?
- When did the ball move a greater distance?
- How is the velocity of the tin related to the kinetic energy?
- In the second situation, how is the mass of the tin related to kinetic energy?

**Learning situation 4**
Asks students to identify the relation among mass, velocity and kinetic energy of

The energy of a body due to its motion is kinetic energy. Kinetic energy of a body depends on the mass and velocity of the body. As the mass increases, kinetic energy also increases. As the velocity of the increases kinetic energy also increases.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Velocity</th>
<th>Kinetic energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td>1 m/s</td>
<td>(\frac{1}{2} \times 1 \times 1^2 = \frac{1}{2} J)</td>
</tr>
<tr>
<td>2 kg</td>
<td>1 m/s</td>
<td>(\frac{1}{2} \times 2 \times 1^2 = 1 J)</td>
</tr>
<tr>
<td>4 kg</td>
<td>1 m/s</td>
<td>(\frac{1}{2} \times 4 \times 1^2 = 2 J)</td>
</tr>
<tr>
<td>1 kg</td>
<td>4 m/s</td>
<td>(\frac{1}{2} \times 1 \times 4^2 = 8 J)</td>
</tr>
<tr>
<td>1 kg</td>
<td>8 m/s</td>
<td>(\frac{1}{2} \times 1 \times 8^2 = 32 J)</td>
</tr>
<tr>
<td>(m)</td>
<td>(v)</td>
<td>(\frac{1}{2} \times m \times v^2)</td>
</tr>
</tbody>
</table>
Find out the formula used for calculating kinetic energy.

Learning situation 5
Asks to give more examples.

Learning situation 6
Asks students to compare the concept with analogy of electrical energy.

**Kinetic energy**

\[ \text{Kinetic energy} = \frac{1}{2}mv^2 \]

*Unit: Joule*

- Flying bird possess kinetic energy
- A coconut is falling from coconut tree
- An arrow flying through the air has kinetic energy

<table>
<thead>
<tr>
<th>Analogy(Current energy)</th>
<th>Concept(Kinetic energy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrons</td>
<td>Massive moving bodies</td>
</tr>
<tr>
<td>Velocity of electrons</td>
<td>Velocity of bodies</td>
</tr>
<tr>
<td>Flow of charges</td>
<td>Motion of bodies</td>
</tr>
<tr>
<td>Current possess energy</td>
<td>Moving bodies possess energy</td>
</tr>
</tbody>
</table>

Current energy is also kinetic. But the difference occurs here is, the mass depends on kinetic energy where as the number of electrons (charges) depends on electrical energy.

Phase IV
Assessing the attainment of concept (CAM)

Phase V
Conceptualizing the concept by mapping with the concept (SM)
### Learning situation 7
Asks students to give new analogies.

#### Closure
Asks students to describe the thought process and asks some thought provoking questions to assess learning. Follow up activities are also provided to assess the learning.
Which would have a greater effect on the kinetic energy of an object: doubling the mass or doubling the velocity?
How much work should be done on a bicycle of mass 20 kg to increase its speed from 2m/s to 5m/s?

Success in business depends on continuous effort and the ability in planning. Here, effort is similar to the velocity of bodies; ability in planning is similar to mass of bodies.

Describe the thought process and find solutions to questions.

### Phase VI
Generating new analogies and explaining the similarities and differences (SM)

### Phase VII
Reflection (constructivism, CAM & SM)
Objectives of the lesson:
The major objectives of the lesson are to attain the concept of potential energy and to develop creative potential of students.

Instructional goals:
Students will be able to
1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘potential energy’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘potential energy’
6. Conceptualize the concept of inertia by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td></td>
<td><strong>Phase I</strong></td>
</tr>
<tr>
<td>Begins with assessment of the essential previous knowledge for the learning of concept, potential energy. Students have attained the concepts of energy, work, mass, velocity, and kinetic energy earlier.</td>
<td>The visuals are observed and formulated hypotheses with the help of the visuals.</td>
<td>Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td><strong>Phase II</strong></td>
</tr>
<tr>
<td>After assessing the entry behaviour, the following situations are provided. Asks to formulate hypotheses for identifying the critical attributes of the concept to be attained.</td>
<td></td>
<td>Providing experiences (CAM)</td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asks students to observe the situations and to formulate hypotheses of the problem posed.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Two balls of different masses are dropped on wet clay from the same height and from different heights (Figure 10. a & Figure 10. b).

**Focusing questions:**
- When the balls are dropped from the same height, which is produced more impact? Why?
- When they are dropped from different heights, what will be the difference in producing impact on clay? Why?
- Find out the possible solutions.
- Are the work done by the balls same?
- How do they get energy to produce the impact?
- Suppose they are on the ground at rest, are they having the capacity to produce impact?

Impact made by the balls depends on the weight of the balls and the height from which the balls fall.
- Greater the weight, bigger is the impact (Figure 10. c).
**Learning situation 2**

Asks students to compare the given positive and negative instances to identify the attributes of the concept. This will also help to confirm the hypotheses formed earlier.

**Positive instances**
- Lifting a weight (Figure 10. e).
- A ball on the top of a hill (Figure 10. f).
- Stretching a rubber band (Figure 10. g).
- A stretched bow (Figure 10. h).
- A stone on the top of a hill (Figure 10. i).
- Compressing a spring (Figure 10. j).

**Negative instances**
- Moving water (Figure 10. k).
- Greater the height, greater is the impact (Figure 10. d).
- They possess energy because they are falling from a particular height.

**Phase III**
Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)
Coconut is falling (Figure 10. l).
A fast moving ball (Figure 10. m).
Fast moving vehicle (Figure 10. n)

**Focusing questions:**
- Do all the given instances possess energy?
- How do they get the capacity to do work?
- Identify the common attributes of the positive instances.
- Identify the concept.

All given instances possess energy. But the common attributes of
Names the concept as ‘Potential energy’.

**Learning situation 3**

Asks to observe the visuals given in the first learning situation again (Figure 10. a, 10. b, 10. c, & 10. d).

Why do the balls produce the impact on the clay in different ways?

What kind of energy they are having?

Asks students to analyze the data given in the table and also asks to find out the factors affecting potential energy and the formula for determining the energy.

The positive instances are

- They possess energy.
- They have the ability to produce any impact.
- They possess energy due to their height or stretching position or compressed position.

So, the concept is energy possessed due to their position.

Identifying the concept

(Naming the concept)

Analyzing the situations

<table>
<thead>
<tr>
<th>Mass of the body (m)</th>
<th>Height at which the mass is placed (h)</th>
<th>Potential energy (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td>1 m</td>
<td>$1 \times 9.8 \times 1 = 9.8 \text{ J}$</td>
</tr>
<tr>
<td>2 kg</td>
<td>1 m</td>
<td>$2 \times 9.8 \times 1 = 19.6 \text{ J}$</td>
</tr>
<tr>
<td>4 kg</td>
<td>3 m</td>
<td>$4 \times 9.8 \times 3 = 117.6 \text{ J}$</td>
</tr>
<tr>
<td>1 kg</td>
<td>2 m</td>
<td>$1 \times 9.8 \times 2 = 19.6 \text{ J}$</td>
</tr>
<tr>
<td>m</td>
<td>h</td>
<td>$m \times g \times h = mgh$</td>
</tr>
</tbody>
</table>
### Focusing questions
- When a body of mass ‘m’ is raised to a height ‘h’ above the surface of the earth, what is force acting on the body?
- What is the direction of gravitational force?
- What will be the work done to lift a body above the surface of the ground against gravity?
- How can you determine potential energy?

### Learning situation 4
Asks students to cite more examples for potential energy.

### Learning situation 5
Analogy of the role of president in a country is provided for the conceptualization of the concept. Asks students to find out the similar

When a body of mass ‘m’ is raised to a height ‘h’, the force acting on the body is the gravitational pull of the earth \((m \times g)\).

Gravitational pull acts in downward direction.

Work done against gravity is \(m \times g \times h\).

**Potential energy** = \(mgh\)

**Unit : Joule**

The energy of a body due to its position or change in shape is potential energy. Potential energy depends on mass of the body \((m)\), height \((h)\) from the ground and acceleration due to gravity\((g)\).

Water in a tank on the roof of a building, compressed gas in a cylinder, a book on the table etc.

President is the head of the nation by virtue of his position. Similarly, a body possesses potential energy by virtue of its position. As the mass increases, potential energy also increases. In the same way, if the ability of the president is higher the level
<table>
<thead>
<tr>
<th>Learning situation 6</th>
<th>Elements of the concept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asks to give new analogies for the concept.</td>
<td>of progress of the nation also will be higher. But this analogy does not apply to the factors acceleration due to gravity and the relation between height and energy.</td>
</tr>
</tbody>
</table>

Energy levels of atom is described and compared with the concept.  
In the case atoms, the higher the levels of it possess the higher the energy. When the electron returns to a low energy state, it releases potential energy in the form of kinetic energy. Similarly, if a body falls from a height, its potential energy stored in it is used in the form of kinetic energy in producing an impact. But there are differences between the analogy and the concept. Potential energy depends on mass, g and height. No similarity for the factors of potential energy is found in the analogy of energy levels. |

<table>
<thead>
<tr>
<th>Closure</th>
<th>Thought process is described and solutions to questions are found out.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asks students to describe the thinking process. Asks thought provoking questions to assess the learning.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase VI</th>
<th>Generating new analogies and explaining the similarities and differences (SM)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Phase VII</th>
<th>Reflection (constructivism, CAM &amp; SM)</th>
</tr>
</thead>
</table>
Objectives of the lesson:
The major objectives of the lesson are to attain the concept of force and to develop creative potential of students.

Instructional goals:-
Students will be able to
1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept force
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Force’
6. Conceptualize the concept of force by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behavior</strong>&lt;br&gt;The lesson begins with assessing the essential previous knowledge for the learning of concept ‘force’. Students have attained the concepts of mass, velocity and acceleration earlier.&lt;br&gt;&lt;br&gt;<strong>Learning situations</strong>&lt;br&gt;After assessing the entry behavior, the following situations are provided. Asks students to analyze the given situations and frame hypotheses to find out the major attributes of the concept.&lt;br&gt;&lt;br&gt;<strong>Learning situation 1</strong>&lt;br&gt;1. Presents the visuals describing different situations. In Figure 1. a, two girls are pushing a box of mass</td>
<td></td>
<td><strong>Phase I</strong>&lt;br&gt;Testing the entry behaviour (several theories)&lt;br&gt;&lt;br&gt;<strong>Phase II</strong>&lt;br&gt;Providing experiences (CAM)</td>
</tr>
</tbody>
</table>
40 kg. In Figure 1. b, instead of two girls, one boy is pushing the same box. What would happen if one boy pushed the box?

2. Figure 1. c shows the pulling of two stones of different masses by two boys.

Asks students to analyze these situations and formulate hypotheses regarding the relation between push exerted and velocity of the body and also the relation between the pull and mass of the body.

**Focusing questions:-**

1. Compare the push exerted in situation 1. a & 1. b
2. In this case, which box moves faster?
3. What is the relation between push exerted and velocity of the box?

The given situations are observed and analyzed.

<table>
<thead>
<tr>
<th>Figure 1. a. Pushing a box</th>
<th>Figure 1. b. Pushing the box by one boy</th>
</tr>
</thead>
</table>

| Figure 1.c. Pulling of two different stones |

- When we push harder, the body moves faster
- Push or pull is directly proportional to velocity
- Push or pull is directly proportional to mass of the body

Analyzing the situations

Formulating hypotheses

(CAM)
4. In Figure 1. c, relate the pull exerted by students and mass of the bodies

Learning situation 2
Asks students to observe the picture (Figure 1. d) carefully and to think about the relation between the push exerted on the cart and acceleration.

Focusing questions:-
- If the pushing on the cart is the same and the mass increases, what change occurs in the acceleration of the loaded cart?
- If we push harder, what will happen to its acceleration?

Learning situation 3
Asks to identify more critical attributes involved in the concept regarding the nature of push or pull by observing and analyzing the situation. If the pushing is the same, the acceleration of the empty cart is greater than the acceleration of the loaded cart. When we push harder, acceleration increases. Pushing is directly proportional to the mass.
comparing positive and negative instances. This will give the complete picture of the concept. **Positive instances**
- Pushing a cart
- Pulling a carrot
- Swinging
- Heading a ball
- Stopping a ball
- Moving car

**Negative instances**
- Books are kept on table
- Bench at rest
- A ball is moving continuously
- A sponge is kept in a box

**Focusing questions**
- Identify the critical attributes present in positive instances which are not present in

The given positive and negative instances are compared and categorized with the help of the focusing questions.

**Positive instances:**

- Figure 1. e. Pushing a cart
- Figure 1. f. Pulling a carrot
- Figure 1. g. Swinging
- Figure 1. h. Heading a ball

- Figure 1. i. Stopping a ball
- Figure 1. j. Moving car

Analyzing the situations (CAM)

using the critical attributes (CAM)
negative instances.

- Identify the attribute which is necessary to move a body?
- What is the effect of push or pull in the given instances?

Asks students to identify the concept.

<table>
<thead>
<tr>
<th>Negative instances:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1. k. Books are kept on table</td>
</tr>
<tr>
<td>Figure 1. l. Bench at rest</td>
</tr>
</tbody>
</table>

- A push or pull on a body produces motion of the body
- A push or pull can make a change the speed of the body
- A push or pull can change the direction of the moving body
- A push or pull can stop the motion of a body

A push or pull which changes the state of rest or of uniform motion of a moving body in a straight line. As the push or pull increases, acceleration of the body increases.

The amount of push or pull applied on the body increases as the mass increases.

Hypothesizing and identifying the critical attributes (CAM)

Identifying the concept

Naming the concept
Learning situation 4

Asks students to find out the relation between force, mass (m) and acceleration (a) with the help of the data given and restate the definition of the concept.

<table>
<thead>
<tr>
<th>Force (F)</th>
<th>M</th>
<th>a</th>
<th>ma</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_1 = 15$</td>
<td>$m_1 = 5$</td>
<td>$a_1 = 3$</td>
<td>$m_1a_1 = ?$</td>
</tr>
<tr>
<td>$F_2 = 21$</td>
<td>$m_2 = 7$</td>
<td>$a_2 = 3$</td>
<td>$m_2a_2 = ?$</td>
</tr>
<tr>
<td>$F_3 = 32$</td>
<td>$m_3 = 8$</td>
<td>$a_3 = 4$</td>
<td>$m_3a_3 = ?$</td>
</tr>
<tr>
<td>$F_4 = 90$</td>
<td>$m_4 = 15$</td>
<td>$a_4 = 6$</td>
<td>$m_4a_4 = ?$</td>
</tr>
<tr>
<td>F</td>
<td>M</td>
<td>a</td>
<td>F = ?</td>
</tr>
</tbody>
</table>

After analyzing the given data, the relation of force with mass and acceleration is found out.

<table>
<thead>
<tr>
<th>Force (F)</th>
<th>m</th>
<th>a</th>
<th>Mass × acceleration (ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_1 = 15$</td>
<td>$m_1 = 5$</td>
<td>$a_1 = 3$</td>
<td>$m_1a_1 = 15$</td>
</tr>
<tr>
<td>$F_2 = 21$</td>
<td>$m_2 = 7$</td>
<td>$a_2 = 3$</td>
<td>$m_2a_2 = 21$</td>
</tr>
<tr>
<td>$F_3 = 32$</td>
<td>$m_3 = 8$</td>
<td>$a_3 = 4$</td>
<td>$m_3a_3 = 32$</td>
</tr>
<tr>
<td>$F_4 = 90$</td>
<td>$m_4 = 15$</td>
<td>$a_4 = 6$</td>
<td>$m_4a_4 = 90$</td>
</tr>
</tbody>
</table>

Describing the nature of the concept

**Force = mass × acceleration**

*Force is that which changes or tends to change the state of rest or of uniform motion of a body in a straight line.*

*A force can move a stationary body; it can change the speed of a moving body; it can change the direction of a moving body; it can change the shape or size of a body.*
Learning situation 5
Generate new examples for describing the concept, Force

Learning situation 6
An analogy for the concept, ‘force’ is provided. Asks students to think the concept in a divergent way.

Water is continually being lost from leaves by transpiration. This loss of water in the leaves exerts a pull on the water in the xylem duct and draws more water into the leaf. It is just like drinking of water using straw. (Figure 1. m)

Transpiration pull of trees is greater than that of small plants.

Compare the pulling on the water and the relation between the number of

- Stretching a rubber band
- When we walk, we put a push on the ground
- Kicking a football
- A moving toy is pulled to stop

The given analogy is compared with the concept.

![Figure 1. m. Transpiration pull of plants]

The pulling exerted by the loss of water in leaves is similar to the force.

Due to the pull on the water, water moves from the root to the leaves.

When mass increases, we should apply more force to move a
Leaves and the rate of transpiration with the target concept force.

**Learning situation 7**

Suggests to cite new analogies and to describe those through mapping with the concept.

**Closure**

Asks students to describe the thought process and asks some thought provoking questions to assess learning.

Find out more life situations involving force.

Body. Similarly, more leaves will result in a greater amount of water loss and an increased surface area for evaporation. This will increase the transpiration rate or will increase the pull.

New analogies are generated and described.

For example,

- Strength and existence of any political party depends on the support given by the people.
- Our consciousness is the product of wakefulness and the content.

Re-explore the topic by analyzing the thought process and finding answers to questions.

More situations describing the concept, force are identified.

**Phase VI**

Generating new analogies and explaining the similarities and differences (SM)

**Phase VII**

Reflection (constructivism, CAM & SM)
LESSON TRANSCRIPT: 2

TOPIC: MOMENTUM

Objectives of the lesson:

The major objectives of the lesson are to attain the concept of momentum and to develop creative potential of students

Instructional goals:-

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Momentum’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Momentum’
6. Conceptualize the concept of momentum by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The lesson begins with assessing the essential prerequisites for the learning of the concept. Here, the concepts of force, mass and velocity have been taught earlier. Students have attained the concepts earlier. <strong>Learning situations</strong></td>
<td></td>
<td><strong>Phase I</strong> Testing the entry behaviour (Several theories)</td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Hitting a cricket ball using a bat (Figure 2.a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Hit harder than in the previous case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Hit a shot put ball using the same bat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The given situations are observed and analyzed.
### Focusing questions:

- i. Compare the mass and velocity of the bodies given in three situations.
- ii. Which is harder to stop?
- iii. As the applied force increases what will happen to the velocity of the moving body?
- iv. When the mass or the velocity of the body increases, what will happen to the nature of the force applied to stop the body?

### Learning situation 2

Asks students to confirm the formulated hypotheses and to identify the critical attributes by comparing the given positive and negative instances of the concept.

### Positive instances:

- A karate player strikes a pile of tiles or a

### Figure 2. a

Formulate the hypotheses to identify major features of these situations.

- As the mass increases, velocity of the moving body decreases.
- When the exerted force increases, the body will move with greater velocity.
- As the mass increases, it is harder to stop.
- The fast-moving object will require more force to stop it than a slow-moving object.

The two sets of instances are compared and the critical attributes of the concept are identified.

---

**Phase III**

Categorizing and identifying the concept using the critical attributes (CAM)
slab of ice with his hand very fast (Figure L. 2 b).
✓ A fast moving cricket ball may hurt the batsman.
✓ Road accidents at high speed are very much worse than at lower speed.

**Negative instances:**
- A man is holding a pile of tiles.
- A ball is lying on the ground.
- A truck is parked near the shop.

**Focusing questions:**
- Why the karate player can strike a pile of tiles with hand very ‘fast’?
- Why is it harder to stop a fast moving ball?
- Identify the main features of the positive instances which are not present in negative instances.
- What kind of impact produced by a fast moving vehicle?

<table>
<thead>
<tr>
<th>Positive instances</th>
<th>Negative instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ A karate player strikes a pile of tiles or a slab of ice with his hand very fast (Figure L. 2 b).</td>
<td>✓ A man is holding a pile of tiles.</td>
</tr>
<tr>
<td>✓ A fast moving cricket ball may hurt the batsman.</td>
<td>✓ A ball is lying on the ground.</td>
</tr>
<tr>
<td>✓ Road accidents at high speed are very much worse than at lower speed.</td>
<td>✓ A truck is parked near the shop.</td>
</tr>
</tbody>
</table>

**Figure L.2 b**

Formulating hypotheses and identifying the critical attributes (CAM)
Whether a body possesses both mass and velocity when it is at rest?

Asks students to identify the concept on the basis of the attributes identified.

Names the concept as ‘Momentum’

**Learning situation 3**

Asks to find out the quantity of motion with the help of the data given and to describe the nature of the concept.

<table>
<thead>
<tr>
<th>Mass (m)</th>
<th>Velocity (v)</th>
<th>mass × velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_1 = 2$ kg</td>
<td>$v_1 = 40 \text{ m/s}$</td>
<td>$m_1 v_1 = ?$</td>
</tr>
<tr>
<td>$m_2 = 2$ kg</td>
<td>$v_2 = 60 \text{ m/s}$</td>
<td>$m_2 v_2 = ?$</td>
</tr>
<tr>
<td>$m_3 = 4$ kg</td>
<td>$v_3 = 60 \text{ m/s}$</td>
<td>$m_3 v_3 = ?$</td>
</tr>
<tr>
<td>$m_4 = 4$ kg</td>
<td>$v_4 = 80 \text{ m/s}$</td>
<td>$m_4 v_4 = ?$</td>
</tr>
</tbody>
</table>

Greater force is needed for a body to move fast.
- Fast moving body exerts a greater impact.
- A massive object exerts a greater impact than a light object.
- A force is required to stop a moving body.
- A fast-moving massive object will require more force to stop it than a slow-moving light object.
- All moving bodies possess both mass and velocity.

Identifying the concept (CAM)

Naming the concept (CAM)

Describing the nature of the concept

<table>
<thead>
<tr>
<th>Mass (m)</th>
<th>Velocity (v)</th>
<th>mass × velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_1 = 2$ kg</td>
<td>$v_1 = 40 \text{ m/s}$</td>
<td>$m_1 v_1 = 80 \text{ kgm/s}$</td>
</tr>
<tr>
<td>$m_2 = 2$ kg</td>
<td>$v_2 = 60 \text{ m/s}$</td>
<td>$m_2 v_2 = 120 \text{ kgm/s}$</td>
</tr>
<tr>
<td>$m_3 = 4$ kg</td>
<td>$v_3 = 60 \text{ m/s}$</td>
<td>$m_3 v_3 = 240 \text{ kgm/s}$</td>
</tr>
<tr>
<td>$m_4 = 4$ kg</td>
<td>$v_4 = 80 \text{ m/s}$</td>
<td>$m_4 v_4 = 320 \text{ kgm/s}$</td>
</tr>
</tbody>
</table>

All moving bodies possess mass and velocity. As the mass of the body increases, the impact produced by the
Learning situation 4
Asks students to give more examples for the concept, momentum.

body increases. Similarly, as the velocity increase, the impact produced also increases.

Momentum is directly proportional to mass and velocity.

\[ \text{Momentum} (p) = \text{mass} (m) \times \text{velocity} (v) \]

The unit of momentum is \( \text{kgm/s} \).

- A fast moving bullet causes more impact
- It is harder to stop a fast moving baseball
- The accident produced by a truck is greater than by a car

Phase IV
Assessing the attainment of concept (CAM)

Phase V
Conceptualizing the concept by mapping with analogy (SM)

Learning situation 5
The ‘word’ momentum is a part of everyday life.
Suggests an analogy to compare with the concept ‘momentum’
In athletics, the support given by the
coach inspires the team to gain a fast record.

   Identify the similarities and differences (if any) between the analogy and the target concept ‘momentum’.

Focusing questions:-
✓ What impact is produced by the inspiration given by the coach?
✓ What effect is produced by the team which has got a lot of momentum?

Learning situation 6
Gives directions to cite more suitable analogies and to describe those through mapping with concept.

Closure
Asks students to describe the thought process followed. Asks questions to assess the learning.

<table>
<thead>
<tr>
<th>Analogy</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast record</td>
<td>Impact produced by the body</td>
</tr>
<tr>
<td>Move of the team</td>
<td>Body</td>
</tr>
<tr>
<td>Support given by the coach</td>
<td>Force applied on the body</td>
</tr>
<tr>
<td>Racing speed</td>
<td>Velocity of the body</td>
</tr>
<tr>
<td>Team coordination</td>
<td>Mass of the body</td>
</tr>
</tbody>
</table>

More analogies are generated and described. For example: In the realm of politics, it is hard to stop the politician, if he gains in public opinion polls. Here, he has gained ‘momentum’.

Describe the thought process.
Re-explore the topic.

Phase VI
Generating new analogies and explaining the similarities and differences (SM)

Phase VII
Reflection
(Constructivism, CAM & SM)
Objectives of the lesson:

The major objectives of the lesson are to attain the concept of unbalanced external force
and to develop creative potential of students

Instructional goals:-

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Unbalanced force’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept “Unbalanced external force’
6. Conceptualize the concept of Unbalanced force by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The lesson begins with assessing the essential prerequisites for the learning of the concept. Here, the concepts of force, motion and displacement have been taught earlier. Students have attained the concepts earlier.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After assessing the entry behavior, the following situations are provided. Asks students to analyze the given situations and develop hypotheses to find out the major attributes of the concept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students are asked to observe the situations showing in the picture</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phase I</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing the entry behaviour (Several theories)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phase II:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Providing experiences (CAM)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
carefully and analyze the situations to find out the hypotheses of the problem presented.

**Focusing questions:**

- In situation 1, what will be the net force?
- In which direction it has moved in the 2nd situation? Why?
- What will happen to the wishbone in the 3rd case?

**Learning situation 2**

Asks students to observe the instances carefully and identify all the critical attributes of the concept by comparing the given positive and negative forces acting on the wishbone.

Analyze the given situations and formulate the following hypotheses.

- An external force is required to move an object.
- The object will move in the direction of the larger force applied.
- When forces are not the same, the resultant force will not be zero.

The visuals presented are observed and hypotheses are formulated through discussion.

**Figure 3. a. Forces acting on the wishbone**

**Formulating hypotheses**

**Phase III**

Categorizing and identifying the concept using the critical attributes (CAM)
negative instances.

**Positive instances:**
- Pushing a car from one side
- Pulling a block from one side
- Two different forces act on a block
- Tug-of-war

**Negative instances:**
- Pushing a car from opposite sides with equal forces
- Pulling a block with equal forces
- Two equal forces acting on a block
- Tug-of-war with equal forces

**Focusing questions:**
- Identify the forces acting in each case.
- What will be the net force acting in each instance?

Figure 3.b. Pushing a car

Figure 3.c. Pulling a block

\[ F_1 = 100 \text{ N} \quad F_2 = 200 \text{ N} \]

Figure 3.d. Two forces acting on a block

Figure 3.e. Tug-of-war
- Identify the major features of cases given under positive instances.
- Identify the major features of negative instances.

**Negative instances:**

- Figure 3. f. Pushing a car from opposite sides
- Figure 3. g. Pulling a block with equal forces
  \[ F_1 = 100 \text{ N} \quad F_2 = 100 \text{ N} \]
- Figure 3. h. Two forces acting on a block
- Figure 3. i. Tug-of-war
<table>
<thead>
<tr>
<th><strong>Lesson Transcripts xxxix</strong></th>
<th><strong>Balanced forces.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asks students to identify the concept.</td>
<td></td>
</tr>
<tr>
<td>The concept is named as ‘<em>Unbalanced external forces</em>’. When the forces are equal, what will be the concept? <strong>Learning situation 3</strong></td>
<td>Asks students to describe the</td>
</tr>
<tr>
<td><strong>All moving bodies are experienced by external forces.</strong></td>
<td><strong>Formulating hypotheses and identifying the critical attributes (CAM)</strong></td>
</tr>
<tr>
<td><strong>The forces applied on the body are unequal and in opposite direction.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>The resultant of these forces is not zero</strong></td>
<td></td>
</tr>
<tr>
<td><strong>The body moves in the direction of greater force.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>To move a stationary object, we have to exert a force greater than the opposing force acting on it.</strong></td>
<td></td>
</tr>
<tr>
<td>When the forces act on a body are not equal and in opposite direction, they produce a change in its state of rest or of uniform motion. The body will move in the direction of larger force.</td>
<td></td>
</tr>
<tr>
<td><strong>Balanced forces.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Identifying the concept</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Naming the concept (CAM)</strong></td>
<td></td>
</tr>
</tbody>
</table>
concept with the help of the situation given.

Asks to link two Newton meters as shown in Figure 4.j and to pull one end of the Newton meter is harder than the on the other. Repeat the experiment by pulling equally hard from both ends (Figure 4.k).

**Focusing questions:**

What happens if the pull on one end of the Newton meter is harder than on the other?

What will be the net force in two cases?

Are the forces exerted same in both cases?

In the first situation, the forces acting on the hooks are no longer balanced. Both hooks will start to move to the left. So unbalanced forces lead to change in speed or direction. The net force will not be zero. But in the second situation, the resultant force of balanced force is zero.
Learning situation 4
Presents some examples and asks to classify the concepts as balanced and unbalanced forces.
✓ A falling stone
✓ A floating ship
✓ Pushing a trolley
✓ Holding a suitcase
✓ A heavy box is kept on the ground
Asks to identify more examples of

The forces acting on the central hooks cancel each other out, because they are equal and opposite in direction. As the forces are balanced, the hooks do not move.

If the resultant of all the forces acting on a body is zero, the forces are called balanced forces.

If the resultant of all the forces acting on a body is not zero, the forces are balanced forces. The unbalanced forces can produce motion in a stationary body or stop a moving body.

The given examples are classified into balanced and unbalanced forces. New examples of the concept, unbalanced forces are given.
For example,
- Lifting a box
- An aero plane taking off
- Pulling a rope
- Pushing a heavy box

Phase IV
Assessing the attainment of concept (CAM)
the concept unbalanced forces.

**Learning situation 5**

Provides an analogy, spring tides (Figure 4.1) and asks to compare with the concept, unbalanced force with the help of the table given.

<table>
<thead>
<tr>
<th>Spring tide</th>
<th>Unbalanced force</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Sea water</td>
<td>*</td>
</tr>
<tr>
<td>● Collective gravitational pull of moon and sun on the earth’s water.</td>
<td>*</td>
</tr>
<tr>
<td>● Rising of sea water due to the collective pull is strongest.</td>
<td>*</td>
</tr>
</tbody>
</table>

The visual showing spring tides is observed.

The elements of the concept are compared with the elements of the analogy. Similarities and differences (if any) are identified and the concept, unbalanced external forces are described in a more creative way.

**Phase V**

Conceptualizing the concept by mapping with the concept (SM)

**Figure 4.1. Spring tides at new moon and full moon days**

<table>
<thead>
<tr>
<th>Spring tide</th>
<th>Unbalanced force</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Sea water</td>
<td>● Body</td>
</tr>
<tr>
<td>● Collective gravitational pull of moon and sun on the earth’s water.</td>
<td>● External forces acting on a body</td>
</tr>
<tr>
<td>● Rising of sea water due to the collective pull is strongest.</td>
<td>● Unbalanced external forces make the body move.</td>
</tr>
<tr>
<td>Learning situation 6</td>
<td>Phase VI</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Directions to suggest more analogies are given. Asks students to explain the concept of unbalanced force.</td>
<td>Generating new analogies and explaining the similarities and differences (SM)</td>
</tr>
<tr>
<td><strong>Closure</strong></td>
<td></td>
</tr>
<tr>
<td>Asks students to describe the thinking process followed for conceptualizing the concept. Asks thought provoking questions to assess learning.</td>
<td></td>
</tr>
</tbody>
</table>
| New analogies are explained. For example,  
- Common balance used for measuring weights of things: - when the weights on the pans are balanced, the beam is balanced at its mid-point on a knife-edge. Otherwise, the pan which contains larger weight will go down.  
  The thought process is described and the topic is re-explored through answering the questions. | | |
Objectives of the lesson:

The major objectives of the lesson are to attain the concept of inertia and to develop creative potential of students

Instructional goals:

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Inertia’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Inertia’
6. Conceptualize the concept of inertia by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
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<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td>Begins with assessment of the required previous knowledge which is essential for the concept, inertia. Students have attained the concepts of unbalanced external force, mass, velocity, state of rest, state of motion, and uniform motion earlier.</td>
<td><strong>Phase I</strong>&lt;br&gt;Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td><strong>Learning situations</strong>&lt;br&gt;After assessing the entry behaviour, the following situations are provided. Asks to formulate hypotheses for identifying the critical attributes of the concept to be attained.</td>
<td><strong>Learning situation 1</strong>&lt;br&gt;Asks to do the experiment (Figure 4. a &amp; Figure 4. b) and to analyze the following situations.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Activity is performed and the situations are observed.</td>
<td></td>
</tr>
</tbody>
</table>
1. Place a card on the tumbler and a heavy coin on the card. Strike the card suddenly.

Narrates a situation of skidding vehicles on wet or icy roads (Figure 4. c).

Asks to discuss the situations with the help of focusing questions posed.

**Focusing questions:-**

- In the first situation, where do you exert force?
- Before exerting force, what will be the state of the coin?
- What happens to the coin when the card flies off?
- In situation 2, identify the state of car before skidding.
- Why does it skid when the brakes are applied suddenly?

Analyzing the situations and formulating hypotheses (CAM)
Learning situation 2
Presents some positive and negative instances of a concept.

**Positive instances**
1. Push a chair to keep it moving across the floor.
2. When a bus starts moving suddenly a standing passenger tends to fall backwards.
3. To pluck mangoes we shake the branches of the tree (Figure 4.d).

**Negative instances**
1. When a fast moving bus is suddenly stopped, a standing passenger tends to fall forward (Figure 4.e).

- As the coin does not experience any external force, it continues its state of rest.
- The car continues its state of motion when the brakes are applied suddenly.

Analyze the situations given and observe the situations presented.

Figure 4. d. Plucking mangoes (positive instance)

---

**Phase III**
Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)
2. When we stop the pedaling of a fast moving bicycle, it will come to rest after travelling some distance (Figure 4.f).

3. A person jumping out of a moving train may fall forward

**Focusing questions**
- Identify the state of objects before applying the force.
- Identify the property they exhibit when an external force exerted on it
- Identify the major features of the positive instances
- Identify the major features of the negative instances

Figure 4. e. Passengers in a fast moving bus (negative instance)

Figure 4. f. Pedaling a bicycle (negative instance)
Asks to identify the concept.

Names the concept as ‘inertia’.

<table>
<thead>
<tr>
<th>Attributes of positive instances are</th>
</tr>
</thead>
<tbody>
<tr>
<td>• External forces act on a body tend to produce motion.</td>
</tr>
<tr>
<td>• A body continues in its state of rest until it is compelled by an external force to change its state of rest.</td>
</tr>
<tr>
<td>• The tendency of a body to remain at rest.</td>
</tr>
</tbody>
</table>

Critical attributes of the negative instances given are

- External forces can stop a moving body.
- A body continues in motion in straight line with a uniform speed unless is compelled by an external force to change its state of uniform motion.
- Tendency of a moving body to continue its state of uniform motion.

A body at rest or of uniform motion continues its position unless acted upon by an external force.

All bodies show a tendency to resist a change in its state of rest or of uniform motion.

Name the concepts involved in the positive and negative instances as ‘inertia of rest’ and ‘inertia of
### Learning situation 3
Asks to discuss some examples of situation involving inertia in daily life.
- Cats and dogs dry their wet fur by shaking their body vigorously.
- Players run a certain distance before throwing a javelin or a cricket ball.
Asks to describe the nature of the concepts, inertia of rest and inertia of motion.

- On shaking, the fur suddenly moves. The water particles have a tendency to remain at rest due to their inertia. Thus the water particles get separated from their fur.
- This is to take advantage of inertia of motion. When they run, they can make a throw to a maximum distance.

*Inertia of rest is the incapability of a body to change itself its state of rest.*

*Inertia of motion is the incapability of a body to change itself its state of uniform motion along a straight line.*

*Therefore, inertia is that property of a body due to which it resists a change in its state of rest or of uniform motion.*

- Athletes run a certain distance before taking a long jump.
- The dust particles in a carpet fall off when it is beaten.

### Learning situation 4
Asks students to give more examples of motion’ respectively.

- Analyzing the situations

- Describing the nature of the concepts

### Phase IV
Assessing the attainment of concept (CAM)
“Inertia”.

**Learning situation 5**
Gives an analogy of acoustic inertia to compare with the concept of inertia and asks to describe the concept, inertia.
Provides a flute and asks to play the flute.
Gives directions to observe the situation and to compare with inertia.

**Learning situation 6**
Gives directions to suggest more analogies to explain the concept of inertia.

**Closure**
Asks to describe the thought process and asks some thought provoking questions to assess learning.
Why do rabbits run in a zig-zag manner to escape from dogs?
Find out more life situations involving inertia.

with a stick.

Play the flute. After discussion, present the similarities of this with the concept.

When we play a flute, a force tends to vibrate the molecules and thus, to produce music. But when it stops, the moving particles show a property to resist its state. So vibrations of air molecules in flute or organ pipes take time to diminish after the forces causing them to stop.

Suggest some analogies such as
- Blades of an electric fan continue to rotate for sometime after current is switched off.
- Inertia means opposition to change. It is similar to human mind. The human mind has inertia. Our mind has a property to resist a change at every suggestion.

Describe the thought process. Find answers to questions are found out and conclude that heavier bodies possess greater inertia.

**Phase V**
Conceptualizing the concept by mapping with the concept (SM)

**Phase VI**
Generating new analogies and explaining the similarities and differences (SM)

**Phase VII**
Reflection (constructivism, CAM & SM)
LESSON TRANSCRIPT: 5

TOPIC: FRICTIONAL FORCE

Objectives of the lesson:

The major objectives of the lesson are to attain the concept of frictional force and to develop creative potential of students

Instructional goals:-

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept frictional force
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Frictional force’
6. Conceptualize the concept of friction by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td></td>
<td><strong>Phase I</strong></td>
</tr>
<tr>
<td>The lesson begins with assessing the essential previous knowledge for the</td>
<td></td>
<td>Testing the entry behaviour</td>
</tr>
<tr>
<td>learning of the concept, ‘friction’. Students have attained the concepts of</td>
<td></td>
<td>(several theories)</td>
</tr>
<tr>
<td>force, mass, balanced &amp; unbalanced forces, acceleration and motion earlier.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td><strong>Phase II</strong></td>
</tr>
<tr>
<td>After assessing the entry behaviour, the following situations are provided.</td>
<td></td>
<td>Providing experiences (CAM)</td>
</tr>
<tr>
<td>Asks students to analyze the given situations and frame hypotheses to find</td>
<td></td>
<td></td>
</tr>
<tr>
<td>out the critical attributes of the concept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asks students to roll a ball on the floor</td>
<td>After performing the activity, the difference occurs in two situations is noted.</td>
<td></td>
</tr>
</tbody>
</table>
of the classroom. What will happen?
Spread a little oil on the floor. Roll the ball. What is the difference between the two situations?

Think about the reason behind this difference.

Learning situation 2
Asks students to observe the given positive and negative instances and to identify all the critical attributes of the concept.

Positive instances
- Walking
- Holding objects
- Writing with a pencil on a paper
- Rubbing your hands together to

Figure 5. a. A ball is rolling on the floor

When we roll a ball on the floor, it stops after sometime, even though we are not applying any force from the opposite direction. But when we spread oil on the floor, it keeps moving on the oiled surface. But the difference is the ball stops shortly after it starts rolling on the plain floor (without oil on it). Because the opposing force becomes less in the second situation

Positive instances

Figure 5. b. walking
Figure 5. b. Holding objects

Phase III
Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)
create warmth

- Bicycle brake helps to slow down

**Negative instances**

- An astronaut waking in space
- Satellites in space

**Focusing questions:**

- Identify the forces acting in each case.
- Why is it very difficult to hold smooth and polished objects?
- An ice skater moves easily on ice. Why?
- When we kick a ball, it moves some distance. But it stops after sometime. Why?
- What will happen when we kick a ball in space? Why?

---

**Figure 5. d. Writing**

**Figure 5. e. Forces acting on the bicycle**

**Negative instances:**

- Figure 5. f. Space walking
- Figure 5. g. Satellites moving in space
Asks students to identify the concept

<table>
<thead>
<tr>
<th>The concept is named as ‘frictional force’.</th>
</tr>
</thead>
</table>

- When we walk, we push forward by pushing backwards on the ground.  
- The smooth or oily surface reduces the opposing force.  
- Ice skater experiences minimum opposing force.  
- As the ground exerts an opposing force on the ball, the rolling ball stops after sometime.  
- Due to the absence of air resistance, the ball never experiences any opposing force.
  - Whenever an object moves over another surface or body, it experiences an opposing force.  
  - The force exerted by the body and the force exerted by the surface are in opposite direction.

A force that resists motion between two objects those are in contact with each other. Smoother surfaces exhibit less opposing force, while rougher surfaces exhibit more opposing force.

<table>
<thead>
<tr>
<th>Hypothesizing and identifying the attributes (CAM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying the concept</td>
</tr>
<tr>
<td>Naming the concept (CAM)</td>
</tr>
</tbody>
</table>
**Learning situation 3**

Asks students to find out the uses of friction in our life. Describe the concept of friction.

**Focusing questions**

- How do automobile brakes work?
- An eraser can rub off the matter written in pencil. How?
- Why do you fix rubber or plastic caps at the leg tips of the furniture?

**Learning situation 4**

Asks students to cite more examples of friction and to identify the surfaces between which friction acts in each example.

- When we apply brakes, the frictional force opposes the motion and finally stops the vehicle.
- Eraser uses friction to rub off the matter.
- Rubber offers very high friction. This will help the furniture remain in their respective places.
  
  Whenever a body moves over another body a force comes into play between the surfaces in contact and parallel to the surfaces. This force, *friction* tries to oppose the motion of one body over the other.

- A match sticks lights up due to friction.
- Friction allows us to draw diagrams on paper.
- Friction helps to brush our teeth.
- Frictional force offered by air helps the parachute to have a slow landing.
Learning situation 6

Analogies are provided. Asks students to compare these with frictional phenomena.

Asks students to join together the teeth of two combs and to move one over the other (Figure 5. i). What do you observe? Repeat this with tooth brushes.

Compare these analogies with the surfaces in contact and frictional phenomena.

- Pyramids or castles can be built of cards because of friction (Figure 5. h).

Figure 5. h

Observe the situations and compare these with the surfaces in contact and frictional phenomena.

In frictional phenomena, the frictional force acts between two surfaces. When one moves over another it tries to oppose the motion of the surface. Friction is more in rough surfaces where as smooth surface exhibits less friction.

Similarly in the case of combs, it experiences more opposing force than in the case of brushes. But both (Figure 5. i) looks like the two surfaces in contact (Figure 5. j).

Phase V

Conceptualizing the concept by mapping with the concept (SM)
Learning situation 7
Asks students to generate more analogies to explain the concept of friction.

More analogies are given. For example,

- Life can be compared with friction. If we are having more trouble in planning anything, we feel uncomfortable. If we reduce this trouble, the

Phase VI
Generating new analogies and explaining the similarities and differences (SM)
### Closure
Asks students to describe the thinking process and asks some thought provoking questions to assess learning. Find out more uses of friction from life situations and identify the situations showing disadvantages of friction. How can reduce friction in those situations.

- Oil flows more freely than honey. The resistance to flow is high in the case of honey.
- Resistance to the flow of current is like friction.

Explain the thinking process used for conceptualizing the concept.
More uses and disadvantages of friction are identified and described.
LESSON TRANSCRIPT: 6

TOPIC: SLIDING AND ROLLING FRICITION

Objectives of the lesson:

The major objectives of the lesson are to attain the concept of sliding and rolling friction and to develop creative potential of students

Instructional goals:-

Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘sliding and rolling friction’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘sliding and rolling friction’
6. Conceptualize the concept of sliding and rolling friction by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td>The lesson begins with assessing the essential previous knowledge for the concept, ‘sliding and rolling friction’. Students have attained the concept of frictional force earlier.</td>
<td></td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td>After assessing the entry behaviour, the following situations are provided. Asks students to analyze the given situations and formulate hypotheses to find out the critical attributes of the concept.</td>
<td></td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td>Asks students to place a block on the table and to push it lightly with hand (Figure 6. a). Now push it</td>
<td></td>
</tr>
</tbody>
</table>
| | The activity is performed and the difference between the two situations experienced is noted. | **Phase I**  
Testing the entry behaviour (several theories) |
| |  | **Phase II**  
Providing experiences (CAM) |
harder. What do you experience?

Now, place the block on rollers and asks students to push it (Figure 6. c).

Identify the difference between the force exerted in two cases.

**Focusing questions:**
- Does the block move when you push the block lightly? Why?
- What will happen when you push it harder? Why?

**Learning situation 2**
Asks students to observe the given positive and negative instances and to identify all the critical attributes of the concepts.

- The block doesn’t move when we push it lightly.
- The block doesn’t move because the applied force and the frictional force are balanced.
- The frictional force and applied force are not balanced
- The block moves when the applied force exceeds the force of friction.
- When we place the block on rollers, the force of friction becomes less.
- When we push lightly, the block moves easily because of the low frictional force.

The situations are analyzed and the attributes of the instances are identified.

**Phase III**
Categorizing and identifying the concept using the critical attributes (CAM)
given in the instances.

- Friction exists between block and the floor when the block slides over the floor (Figure 6. c).
- When a glass block slides over the table top, the force of friction exists between the two surfaces (Figure 6. d).
- Frictional force exists between book and top of the table when we a book slides over the table top (Figure 6. e).

**Negative instances**

- When a tyre of wheel is in contact with the road, frictional force exists between the tyre and the surface of road (Figure 6. f).
- The wheels on the bottom of the
roller skates help to glide across surfaces (Figure 6. g).

- It is easy to push a box when it is placed over the rollers (Figure 6. h).
- The glass box moves easily when is placed over the rollers (Figure 6. i).

**Focusing questions:**

- Identify the major attributes of the positive instances.
- Identify the attributes of the negative instances.

- Force of friction exists between when one surface slides over another surface.
- Force of friction exists between when one surface rolls over another surface.
- A body moves easily when it rolls over a surface.
Asks students to identify the concept which involves in the positive instances.

Names the concept as ‘sliding friction’.

Asks to identify and name the concept involved in negative instances.

Describe the nature of the concept.

**Learning situation 3**

Give more examples for sliding friction and rolling friction.

---

- Force of friction becomes less when a body rolls over a surface.

  A minimum force is required to make a body to slide over a surface.

  Force of friction exists between when one body rolls over a surface. This force of friction is ‘rolling friction’.

  **Sliding friction acts between two surfaces in contact that are sliding against one another whereas rolling friction occurs when a round object rolls on a flat surface. Rolling friction is less than sliding friction.**

  Sliding friction exists in

  - Skiing through the mountains
  - Sliding windows

---
**Learning situation 4**

Analogy for explaining the concepts of sliding and rolling friction is presented.

Conflicts occur between persons having dissimilar ideas or interests are similar to sliding and rolling friction. Explain the similarities and differences between the analogy and the concept.

- Playground slides
- Rolling friction exists in
- Rollers attached to the sliding doors or gates helps to move along a surface
- Sliding gates
- Road rollers

When we slide a box over a surface, frictional force between the box and the surface. This force opposes the motion of the box. If we place the box on rollers, the box moves easily. Frictional force between the surface of the rollers and the surface of the floor is less than sliding friction. So the rollers help to move easily over a surface. Similarly, conflict or clash occurs between persons having dissimilar ideas. Conflicts are similar to sliding friction. To overcome these situations we adopt many measures like respect other’s views or ideas to reduce the conflict. This acts like a roller or any round object in reducing friction.

**Phase V**

Conceptualizing the concept by mapping with the concept (SM)
<table>
<thead>
<tr>
<th>Learning situation 5</th>
<th>New analogies are generated. For example,</th>
<th>Phase VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Give more analogies for explaining</td>
<td>- Movement of persons in foot path of a crowded road.</td>
<td>Generating new analogies and explaining the similarities and differences</td>
</tr>
<tr>
<td>sliding friction.</td>
<td>This situation opposes the motion of persons.</td>
<td>(SM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phase VII</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reflection (constructivism, CAM &amp; SM)</td>
</tr>
</tbody>
</table>

**Closure**

Asks students to describe the thinking process and asks some thought provoking questions to assess learning.

The thinking process used for conceptualizing the concept is explained and answers to the questions are described.
LESSON TRANSCRIPT: 7

TOPIC: WORK

Objectives of the lesson:
The major objectives of the lesson are to attain the concept of work and to develop creative potential of students

Instructional goals:-
Students will be able to

1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Work’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Work’
6. Conceptualize the concept of work by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
<thead>
<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entry behaviour</strong></td>
<td>The situations are observed and analyzed.</td>
<td><strong>Phase I</strong>&lt;br&gt;Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td>The lesson begins with assessing the essential previous knowledge for the learning of concept, ‘work’. Students have attained the concepts like force, displacement and motion earlier.</td>
<td></td>
<td><strong>Phase II</strong>&lt;br&gt;Providing experiences (CAM)</td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After assessing the entry behaviour, the following situations are provided. Asks students to analyze the given situations and formulate hypotheses to find out the critical attributes of the concept.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask a student to stand with a bundle of books on his head. After that, ask him to walk to a certain</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
distance with the bundle. Then, ask him to climb up on the bunch with the books on his head. Asks to identify the force exerted on the books and the direction of displacement of the books.

**Focusing questions:**
- In which direction force is applied on the books, when a boy is standing with a bundle of books on his head? Is there any displacement of books occurs?
- When a boy is walking to a certain distance with the bundle of books, what will be the direction of displacement of books and the upward force.
- When he climbs up on the bench with the books, what will be the direction of displacement and the

<table>
<thead>
<tr>
<th>Books</th>
<th>Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>No displacement of books</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Books</th>
<th>Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- When a boy is standing with a bundle of books on his head, he is applying a force on the books in the upward direction.
- When a boy is walking with the bundle of books, the direction of movement of books is perpendicular to the direction of the upward force.

Analyzing the situations

Hypothesizing (CAM)
upward direction of the force?
- Identify the situation where the direction of displacement is in the direction of the point of application of force.

**Learning situation 2**
Asks students to identify the critical attributes of the concept by comparing the positive and negative instances of the concept.

Positive instances
- A box moves in the direction of pulling (Figure 7. a).
- A wheelbarrow is moving in the direction of pulling (Figure 7. b).
- A ball moves in the direction of kicking (Figure 7. c).
- Pushing a heavy trolley for 10m

- When he climbs up on the bench, the direction of the displacement is in the direction of the upward direction.

![Books Displacement](image)

- When the book is raised to a height, the book is displaced in the direction of the point of application.

**Positive instances**

![Figure 7. a](image)  ![Figure 7. b](image)  ![Figure 7. c](image)  ![Figure 7. d](image)

**Phase III**
Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations
A rocket accelerates through space (figure 7. e).

Negative instances
- Pushing against a wall (Figure 7. f).
- Holding a chair and walking around the classroom (Figure 7. g).
- A waiter carries a tray full of meals above his head by one arm straight across the room at constant speed (Figure 7. h).

Negative instances

Hypothesizing and identifying the critical attributes (CAM)
Names the concept as ‘Work’

**Learning situation 4**

Asks students to analyze the data and find out the work done in each case.

Work done in each case is found out by analyzing the data.

---

**Figure 7. h**

- Force produces motion.
- The body moves in the direction of the applied force.
- The direction of displacement of the body and the direction of applied force are same.

Identifying the concept

Naming the concept (CAM)
### Focusing questions:

- How can we determine the work done?
- Describe the concept Work in physics.
- What is the unit of work done?

---

**Work done in moving a body is equal to the product of force exerted on the body and the distance moved by the body in the direction of force.**

If the point of application of force moves in the direction of force applied on it we say a work is done and if there is no movement of the point of application of force, no work is done.
**Learning situation 5**
Asks students to cite more examples of work.

**Learning situation 6**
Analogy of reputation of school is provided to conceptualize the concept of work.

<table>
<thead>
<tr>
<th>Analogy</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper instruction &amp; administration</td>
<td>Force applied</td>
</tr>
<tr>
<td>Result obtained in public exam</td>
<td>Distance moved</td>
</tr>
<tr>
<td>Reputation of school</td>
<td>Work done</td>
</tr>
</tbody>
</table>

**Work** = $\text{Force} \times \text{Distance moved in the direction of force}$

**Unit:** Nm or joule

- A teacher pulling a boy along on a rope.
- Cutting a piece of cheese
- Striking a match
- Going up in a lift

The given analogy is compared with the concept and described.

**Phase IV**
Assessing the attainment of concept (CAM)

**Phase V**
Conceptualizing the concept by mapping with the concept (SM)
Asks to identify the similar elements of the concept against each element of analogy.

**Learning situation 7**
Asks to give more analogies and to describe those.

**Closure**
Asks students to describe the thinking process and asks some thought provoking questions to assess learning.

<table>
<thead>
<tr>
<th>Phase VI</th>
<th>Generating new analogies and explaining the similarities and differences (SM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New analogies are generated and described.</td>
</tr>
<tr>
<td></td>
<td>✓ Development of a country depends on the governing body of the country.</td>
</tr>
<tr>
<td></td>
<td>✓ Character of an individual depends on his home environment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase VII</th>
<th>Reflection (constructivism, CAM &amp; SM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The thinking process used for conceptualizing the concept is explained and answers to the questions are described.</td>
</tr>
</tbody>
</table>
Objectives of the lesson:
The major objectives of the lesson are to attain the concept of energy and to develop creative potential of students

Instructional goals:-
Students will be able to
1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘energy’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘energy’
6. Conceptualize the concept of energy by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
<table>
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<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
</tr>
</thead>
</table>
| **Entry behaviour** | The lesson begins with assessing the essential previous knowledge for the learning of concept, ‘energy’. Students have attained the concept of work, mass and velocity earlier. | **Phase I**  
Testing the entry behaviour (several theories) |
| **Learning situations** | After assessing the entry behaviour, the following situations are provided. Asks students to analyze the given situations and formulate hypotheses to find out the critical attributes of the concept. | **Phase II**  
Providing experiences (CAM) |
| **Learning situation 1** | Asks students to calculate the work done by two persons. | |
What will be the work done by two persons?
Identify the person who has done more work.
Are both having the ability to do work?
Is the ability to do work the same?

**Learning situation 2**
Asks students to identify the attributes of the concept.

**Positive instances**
- Wind has the capacity to rotate the blades of wind turbines (Figure 8.a).
- Steam is used for generating current, producing chemicals, for oil refining etc. (Figure 8.b).

<table>
<thead>
<tr>
<th>Person</th>
<th>Force</th>
<th>Distance</th>
<th>Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8N</td>
<td>2m</td>
<td>16J</td>
</tr>
<tr>
<td>B</td>
<td>7N</td>
<td>3m</td>
<td>21J</td>
</tr>
</tbody>
</table>

The works done by two persons are not the same.
The person B has done more work than the person A.
Both of them are having the ability to do work. But the amount of energy used in doing the work is different.

The given instances are compared and the attributes are identified.

**Phase III**
Categorizing and identifying the concept using the critical attributes (CAM)
• Moving water has the capacity to turn turbines (Figure 8. c).

**Negative instances**

• Listening music (Figure 8. d)
• A ball kept on the floor (Figure 8. e).
• Observing flowers (Figure 8. f).
• A sponge on the ground (Figure 8. g).

**Focusing questions:**

• Identify the situations where work is done.
• Identify the situations which are having the capacity to do work.
• What are the common attributes of the concept?

Analyzing the situations identifying the critical attributes and the concept (CAM)
<table>
<thead>
<tr>
<th>Learning situation 3</th>
<th></th>
<th>Learning situation 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Names the concept as ‘energy’.</td>
<td>The common attributes of the positive instances are</td>
<td>Give more examples of situations explaining the concept, ‘energy’.</td>
</tr>
<tr>
<td><strong>Learning situation 3</strong></td>
<td>- Force is required to work</td>
<td>✓ A fast moving ball is hitting at the cricket stump.</td>
</tr>
<tr>
<td>Asks students to identify the various forms of energy from our environment. Asks to describe the details.</td>
<td>- The ability to do work</td>
<td><strong>Phase IV</strong></td>
</tr>
<tr>
<td>Solar energy: - To burn things, to prepare food, to generate current, light etc.</td>
<td><strong>The capacity to do work is called ‘energy’</strong></td>
<td>Assessing the attainment of concept (CAM)</td>
</tr>
<tr>
<td>Wind energy: - to generate current, to blow off things</td>
<td>When something or someone does work, the amount of work done is equal to the amount of energy used in doing the work.</td>
<td></td>
</tr>
<tr>
<td>Heat energy; - to generate current, to cook things, to do chemical reactions etc.</td>
<td>Work and energy are so closely related that they have the same unit, the <strong>joule</strong>.</td>
<td></td>
</tr>
<tr>
<td>Fuel energy</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Nuclear energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical energy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Naming the concept (CAM)**

**Describing the nature of the concept**
Learning situation 5
Provides an analogy of money to explain the concept of energy.

<table>
<thead>
<tr>
<th>Analogy</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paying cash</td>
<td>Force applied</td>
</tr>
<tr>
<td>Getting goods</td>
<td>Moved in the direction or change caused</td>
</tr>
<tr>
<td>Spent money for different purpose</td>
<td>Energy is having different forms</td>
</tr>
<tr>
<td>Managing money properly</td>
<td>Efficient utilization of energy</td>
</tr>
</tbody>
</table>

✓ A hammer falling on the nail on a plank.
✓ A boy jumping down from a height.
✓ A coconut is falling from coconut tree.

Asks students to find out similarities and differences (if any) of the analogy, money and the concept, energy.

Comparisons are made and described.

Energy is like money. When we pay cash, we get things which we want. Similarly whenever we apply force,
<table>
<thead>
<tr>
<th>Learning situation 6</th>
<th>the body moves in the direction of force or makes changes in its form. Energy has different forms. Similarly we use money for different purposes. Efficient and proper management of money helps to preserve our economic system. In the same way efficient utilization of energy preserves our environment. Present new analogies for the concept. Energy is like power of position, occupation etc.</th>
<th>Phase VI</th>
<th>Generating new analogies and explaining the similarities and differences (SM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closure</td>
<td>The thinking process used for conceptualizing the concept is explained and answers to the questions are described.</td>
<td>Phase VII</td>
<td>Reflection (constructivism, CAM &amp; SM)</td>
</tr>
</tbody>
</table>
Objectives of the lesson:
The major objectives of the lesson are to attain the concept of kinetic energy and to develop creative potential of students

Instructional goals:-
Students will be able to
1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘Kinetic energy’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘Kinetic energy’
6. Conceptualize the concept of inertia by mapping the concept with analogy
7. Generate and describe new analogies
8. Develop cognitive thinking skills
9. Develop creative thinking skills
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<tr>
<th>What teacher does</th>
<th>What students do</th>
<th>Phases &amp; Tasks (Principles used)</th>
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<td><strong>Entry behaviour</strong></td>
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<td><strong>Phase I</strong></td>
</tr>
<tr>
<td>Begins with assessment of the essential previous knowledge for the learning of concept, kinetic energy. Students have attained the concepts of energy, work, mass, and velocity earlier.</td>
<td></td>
<td>Testing the entry behaviour (several theories)</td>
</tr>
<tr>
<td><strong>Learning situations</strong></td>
<td></td>
<td><strong>Phase II</strong></td>
</tr>
<tr>
<td>After assessing the entry behaviour, the following situations are provided. Asks to formulate hypotheses for identifying the critical attributes of the concept to be attained.</td>
<td>The visuals are observed and formulated hypotheses with the help of focusing questions.</td>
<td>Providing experiences (CAM)</td>
</tr>
<tr>
<td><strong>Learning situation 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asks students to observe the</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


situations and to identify the attributes.

1. Flowing water on a water wheel (Figure 9.a).
2. A fast moving ball hits the wicket (Figure 9.b).

**Focusing questions:**

**Situation 1**
- What does happen when water flows on the wheel?
- How did the wheel get the ability to turn?
- How did the flowing water get the ability to turn the wheel?

**Situation 2**
- What does happen when the ball hits the wicket?
- How did the ball get the

- A flowing water has the ability to do work
- A moving ball has the ability to do work.

Analyzing the situations and formulating hypotheses (CAM)
ability to push back the stumps?

**Learning situation 2**
Asks students to observe and compare the positive and negative instances of the concept.

**Positive instances**
- A moving hammer drives a nail into wood (Figure 9. c).
- Moving wind turns the blades of the turbine (Figure 9. d).
- A running car (Figure 9. e).

**Negative instances**
- Toys placed on the table (Figure 9. f).
- A stretching rubber band

<table>
<thead>
<tr>
<th>Positive instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 9. c</td>
</tr>
<tr>
<td>Figure 9. d</td>
</tr>
<tr>
<td>Figure 9. e</td>
</tr>
</tbody>
</table>

The following instances are analyzed and the critical attributes of the concept are identified.

**Phase III**
Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)
has the ability to do work (Figure 9. g)

- A ball placed at the top of the steps (Figure 9. h).

Asks to identify the concept.

**Negative instances**

- Possess the ability to do work.
- Moving bodies
- Bodies possess energy due to its motion.

All moving bodies possess energy due to its motion.

Hypothesizing and identifying the critical attributes (CAM)
Names the concept as ‘Kinetic energy’.

**Learning situation 3**

Asks students to keep a smooth plank of wood 1m long inclined. Keep a rubber ball on the ground, a little in front of the plank and mark the position. Roll down an empty tin from the top of the plank. The tin will hit the ball causing it to move forward. Measure and note the distance the ball moved. Fill the tin with sand and repeat the experiment.

Roll down the tin filled with sand and empty tin from the same height of the inclined plane and note down the

The activity is performed and the observations are noted.

- When the tin rolls down from different heights, the tin possess kinetic energy and the amount of energy differs.
- When the tin placed at greater height, it acquires more velocity.
- As the velocity increases, kinetic energy increases.
- The tin filled with sand acquires more energy.
- As the mass increases, kinetic energy also increases.

Identifying the concept (CAM)

Naming the concept (CAM)

Analyzing the situations and formulating hypotheses
distance moved by the ball.

**Focusing questions:**
- On which situation did the ball move to a greater distance?
- When the tin rolls down from different heights, what happens to the ball?
- When did the ball move a greater distance?
- How is the velocity of the tin related to the kinetic energy?
- In the second situation, how is the mass of the tin related to kinetic energy?

**Learning situation 4**
Asks students to identify the relation among mass, velocity and kinetic energy of

The energy of a body due to its motion is kinetic energy. Kinetic energy of a body depends on the mass and velocity of the body. As the mass increases, kinetic energy also increases. As the velocity of the increases kinetic energy also increases.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Velocity</th>
<th>Kinetic energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td>1 m/s</td>
<td>( \frac{1}{2} \times 1 \times 1^2 = 0.5 \text{J} )</td>
</tr>
<tr>
<td>2 kg</td>
<td>1 m/s</td>
<td>( \frac{1}{2} \times 2 \times 1^2 = 1 \text{J} )</td>
</tr>
<tr>
<td>4 kg</td>
<td>1 m/s</td>
<td>( \frac{1}{2} \times 4 \times 1^2 = 2 \text{J} )</td>
</tr>
<tr>
<td>1 kg</td>
<td>4 m/s</td>
<td>( \frac{1}{2} \times 1 \times 4^2 = 8 \text{J} )</td>
</tr>
<tr>
<td>1 kg</td>
<td>8 m/s</td>
<td>( \frac{1}{2} \times 1 \times 8^2 = 32 \text{J} )</td>
</tr>
<tr>
<td>m</td>
<td>v</td>
<td>( \frac{1}{2} \times m \times v^2 )</td>
</tr>
</tbody>
</table>
Find out the formula used for calculating kinetic energy.

### Learning situation 5
Asks to give more examples.

### Learning situation 6
Asks students to compare the concept with analogy of electrical energy.

**Kinetic energy**

\[
\text{Kinetic energy} = \frac{1}{2}mv^2
\]

**Unit: Joule**

- Flying bird possess kinetic energy
- A coconut is falling from coconut tree
- An arrow flying through the air has kinetic energy

<table>
<thead>
<tr>
<th>Analogy (Current energy)</th>
<th>Concept (Kinetic energy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrons</td>
<td>Massive moving bodies</td>
</tr>
<tr>
<td>Velocity of electrons</td>
<td>Velocity of bodies</td>
</tr>
<tr>
<td>Flow of charges</td>
<td>Motion of bodies</td>
</tr>
<tr>
<td>Current possess energy</td>
<td>Moving bodies possess energy</td>
</tr>
</tbody>
</table>

**Phase IV**
Assessing the attainment of concept (CAM)

**Phase V**
Conceptualizing the concept by mapping with the concept (SM)

Current energy is also kinetic. But the difference occurs here is, the mass depends on kinetic energy where as the number of electrons (charges) depends on electrical energy.
<table>
<thead>
<tr>
<th>Learning situation 7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asks students to give new analogies.</td>
<td>Success in business depends on continuous effort and the ability in planning. Here, effort is similar to the velocity of bodies; ability in planning is similar to mass of bodies.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Closure</th>
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<tbody>
<tr>
<td>Asks students to describe the thought process and asks some thought provoking questions to assess learning. Follow up activities are also provided to assess the learning. Which would have a greater effect on the kinetic energy of an object: doubling the mass or doubling the velocity? How much work should be done on a bicycle of mass 20 kg to increase its speed from 2m/s to 5m/s?</td>
<td>Describe the thought process and find solutions to questions.</td>
</tr>
</tbody>
</table>

<table>
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<td>Reflection (constructivism, CAM &amp; SM)</td>
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</tr>
</tbody>
</table>
Objectives of the lesson:
The major objectives of the lesson are to attain the concept of potential energy and to develop creative potential of students.

Instructional goals:-
Students will be able to
1. Observe learning situations
2. Locate / identify problem
3. Formulate hypotheses to identify critical attributes of the concept ‘potential energy’
4. Identify the concept by comparing the positive and negative examples of the concept
5. Generate examples of the concept ‘potential energy’
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</table>
| **Entry behaviour**  
Begins with assessment of the essential previous knowledge for the learning of concept, potential energy. Students have attained the concepts of energy, work, mass, velocity, and kinetic energy earlier.  
**Learning situations**  
After assessing the entry behaviour, the following situations are provided. Asks to formulate hypotheses for identifying the critical attributes of the concept to be attained.  
**Learning situation 1**  
Asks students to observe the situations and to formulate hypotheses of the problem posed. | The visuals are observed and formulated hypotheses with the help. | **Phase I**  
Testing the entry behaviour (several theories)  
**Phase II**  
Providing experiences (CAM) |
Two balls of different masses are dropped on wet clay from the same height and from different heights (Figure 10.a & Figure 10. b).

**Focusing questions:**
- When the balls are dropped from the same height, which is produced more impact? Why?
- When they are dropped from different heights, what will be the difference in producing impact on clay? Why?
- Find out the possible solutions.
- Are the work done by the balls same?
- How do they get energy to produce the impact?
- Suppose they are on the ground at rest, are they having the capacity to produce impact?

Impact made by the balls depends on the weight of the balls and the height from which the balls fall.
- Greater the weight, bigger is the impact (Figure 10. c).

- Analyzing the situations
- Formulating hypotheses (CAM)
Learning situation 2

Asks students to compare the given positive and negative instances to identify the attributes of the concept. This will also help to confirm the hypotheses formed earlier.

Positive instances

- Lifting a weight (Figure 10. e).
- A ball on the top of a hill (Figure 10. f).
- Stretching a rubber band (Figure 10. g).
- A stretched bow (Figure 10. h).
- A stone on the top of a hill (Figure 10. i)
- Compressing a spring (Figure 10. j).

Negative instances

- Greater the height, greater is the impact (Figure 10. d).
- They possess energy because they are falling from a particular height.

Positive instances

Phase III

Categorizing and identifying the concept using the critical attributes (CAM)

Analyzing the situations (CAM)
- Coconut is falling (Figure 10. l).
- A fast moving ball (Figure 10. m).
- Fast moving vehicle (Figure 10. n)

**Focusing questions:**
- Do all the given instances possess energy?
- How do they get the capacity to do work?
- Identify the common attributes of the positive instances.
- Identify the concept.

<table>
<thead>
<tr>
<th>Figure 10. i</th>
<th>Figure 10. j</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Negative instances</strong></td>
<td></td>
</tr>
<tr>
<td>Figure 10. k</td>
<td>Figure 10. l</td>
</tr>
<tr>
<td>Figure 10. m</td>
<td>Figure 10. n</td>
</tr>
</tbody>
</table>

All given instances possess energy. But the common attributes of
Names the concept as ‘Potential energy’.

**Learning situation 3**

Asks to observe the visuals given in the first learning situation again (Figure 10. a, 10. b, 10. c, & 10. d).

Why do the balls produce the impact on the clay in different ways?

What kind of energy they are having?

Asks students to analyze the data given in the table and also asks to find out the factors affecting potential energy and the formula for determining the energy.

The given data are analyzed and the relation among concepts is determined.

<table>
<thead>
<tr>
<th>Mass of the body (m)</th>
<th>Height at which the mass is placed (h)</th>
<th>Potential energy (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg</td>
<td>1 m</td>
<td>$1 \times 9.8 \times 1 = 9.8$ J</td>
</tr>
<tr>
<td>2 kg</td>
<td>1 m</td>
<td>$2 \times 9.8 \times 1 = 19.6$ J</td>
</tr>
<tr>
<td>4 kg</td>
<td>3 m</td>
<td>$4 \times 9.8 \times 3 = 117.6$ J</td>
</tr>
<tr>
<td>1 kg</td>
<td>2 m</td>
<td>$1 \times 9.8 \times 2 = 19.6$ J</td>
</tr>
<tr>
<td>m</td>
<td>h</td>
<td>$m \times g \times h = mgh$</td>
</tr>
</tbody>
</table>

Identifying the concept (CAM)

Naming the concept (CAM)

Analyzing the situations
Focusing questions

- When a body of mass ‘m’ is raised to a height ‘h’ above the surface of the earth, what is force acting on the body?
- What is the direction of gravitational force?
- What will be the work done to lift a body above the surface of the ground against gravity?
- How can you determine potential energy?

**Learning situation 4**
Asks students to cite more examples for potential energy.

**Learning situation 5**
Analogy of the role of president in a country is provided for the conceptualization of the concept. Asks students to find out the similar

When a body of mass ‘m’ is raised to a height ‘h’, the force acting on the body is the gravitational pull of the earth (m × g).

Gravitational pull acts in downward direction.

Work done against gravity is $m \times g \times h$.

**Potential energy = mgh**

**Unit : Joule**

_The energy of a body due to its position or change in shape is potential energy. Potential energy depends on mass of the body (m), height (h) from the ground and acceleration due to gravity(g)._

Water in a tank on the roof of a building, compressed gas in a cylinder, a book on the table etc.

President is the head of the nation by virtue of his position. Similarly, a body possesses potential energy by virtue of its position. As the mass increases, potential energy also increases. In the same way, if the ability of the president is higher the level
elements of the concept.

**Learning situation 6**
Asks to give new analogies for the concept.

<table>
<thead>
<tr>
<th><strong>Closure</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asks students to describe the thinking process. Asks thought provoking questions to assess the learning.</td>
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</tbody>
</table>

of progress of the nation also will be higher. But this analogy does not apply to the factors acceleration due to gravity and the relation between height and energy.

Energy levels of atom is described and compared with the concept.

In the case atoms, the higher the levels of it possess the higher the energy. When the electron returns to a low energy state, it releases potential energy in the form of kinetic energy. Similarly, if a body falls from a height, its potential energy stored in it is used in the form of kinetic energy in producing an impact. But there are differences between the analogy and the concept. Potential energy depends on mass, g and height. No similarity for the factors of potential energy is found in the analogy of energy levels.

Thought process is described and solutions to questions are found out.

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