ABSTRACT
Flow through porous media in different geometrical configurations is investigated in this thesis using the Brinkman model. The earlier part of this thesis is devoted to the study of dispersion of soluble matter and heat transfer in porous media in vertical channels bounded by straight configurations. The later part of the thesis deals with the flow of an incompressible fluid through porous media in horizontal channels with uniformly varying gap and sinusoidally varying boundaries, the latter being mainly due to peristaltic pumping.

Dispersion of soluble matter through porous media is studied using the concept of Taylor’s dispersion and it is shown that the combined effect of molecular diffusion and advection on the distribution of concentration of a cloud of solute is ultimately to make it spread out symmetrically about a point with the mean velocity $\bar{u}$ which is a function of the permeability of the material. Neglecting molecular diffusion in the axial direction it is shown that the Taylor’s longitudinal diffusivity to be of the form $(P^2 h^4/D) F_1 (\sigma)$ in which $D$ is the molecular diffusivity, $P$ is the pressure gradient, $h$ is the width of the porous bed and $\sigma = h\sqrt{k}$, $k$ being the permeability of the porous material and $F_1 (\sigma)$ is a function given by 3.1.23. The Taylor diffusion coefficient is improved using Aris’ approach and it is shown that the relative diffusivity is the sum of molecular and Taylor diffusivities. Deterministic model for the longitudinal dispersion is developed and it is found that the results are in agreement with the cell model of Simpson and the experimental observations of Harleman et al (1963). In particular, the variation of the diffusion coefficient with the particle size of the porous media is studied.

Dispersion in a vertical channel is also studied with and without the presence of porous media using different boundary conditions and it is shown that in the case of heavier fluids at the bottom ($\alpha_2 > 0$) in upward flow, the velocity of the more dense layer in the centre of the tube is reduced because of the downward buoyant force. As $\alpha_2$ increases it is found that the velocity profiles continue to flatten exhibiting the plug-flow nature. It is also found that for $\alpha_2 > 200$ a point of inflexion exists exhibiting instability. However, for $\alpha_2 < 0$, it is found that the point of inflexion develops at the wall and moves inwards vertically as $\alpha_2$ decreases exhibiting instability in this region.

The free convection in a vertical porous stratum is investigated and it is shown that the porous parameter retards the flow thus exhibiting an effect similar
to that of magnetic field in magnetohydrodynamics. Combined free and forced convection in a vertical porous stratum is also investigated and an effective thermal diffusion coefficient is determined and it is shown that it decreases with increasing porous parameter.

Flow through porous media in curved channels with uniformly varying gap is investigated using different approximations on the slope and curvature of the walls. The general results obtained therein have been applied to a particular case of smooth constriction. The weight functions for different approximations are also calculated and it is found that the average pressure drop calculated from the second and third methods approach each other for large values of \( x/L \).

Flow through porous media in channels bounded by flexible walls, the fluid flow being induced by a sinusoidal travelling wave motion of the walls, is investigated for small and moderate Reynolds number. In the case of small Reynolds number, inertia terms are neglected and perturbation solutions are found for the stream function in powers of the ratio of the amplitude of the variation in channel breadth to the mean breadth. It is shown that the flow is symmetrical about a trough in the boundary with the existence of back flow in regions around the trough. In the case of moderate Reynolds number the peristaltic motion in porous media is studied including inertia terms. It is found that the mean flow induced by the curvature of the walls of a two-dimensional channel is proportional to the square of the amplitude ratio while the velocity profiles depend on the mean pressure gradient. The effect of the porous parameter \( \sigma \) is to flatten the velocity profile and ultimately change its curvature. In particular, it is shown that the presence of porous media makes the perturbation velocity profile an M-shaped one exhibiting two points of inflexion. Pumping against a positive pressure gradient greater than the critical value would result in reflux and in that case it is shown that the effect of the porous parameter is to reduce the back flow. In other words, the reflux in the centre region can be prevented by selecting a suitable value of the porous parameter \( \sigma \). The velocity profile and the values of the critical pressure gradient are presented and the effect of the friction offered by the solid particles to the fluid flow is brought out.