Module III:

1. Derive second order accurate, one-sided finite difference approximations for $\partial f/\partial x$, $\partial^2 f/\partial y^2$ and $\partial^2 f/\partial x\partial y$ on a uniform grid.

2. Derive fourth-order accurate central approximates for the above second derivates on a uniform grid.

3. Derive third-order one-sided approximations for the first derivative on a uniform grid.

4. Derive second order accurate central and one-sided approximations for the three derivates on a non-uniform grid.

5. Investigate the consistency condition for the explicit FTBS, FTFS and FTCS schemes for (a) unsteady advection equation with no diffusion, and (b) unsteady diffusion equation with no advection.

6. Investigate the stability condition for the explicit and the implicit form of the three schemes mentioned in #5 above.

7. Show that the DuFort-Frankel scheme for the unsteady diffusion is second-order accurate and unconditionally stable.

8. Explore the accuracy, consistency and stability of (a) the Beam-Warming scheme, and (b) the MacCormack scheme for the unsteady advection case.

9. Investigate the schemes in problem #5, Module III *numerically* to bring out their diffusive/dispersive errors.

10. Use the higher order approximations that you have derived in problems #1 to #3, Module III to investigate their error behaviour *numerically*using either the unsteady advection or the unsteady diffusion equation, as appropriate.

11. Derive the stability condition for the one-dimensional unsteady convection-diffusion equation for FT-CS-CS, FT-BS-CS schemes in their explicit form.

12. Repeat the above problem numerically as a case study like that discussed in Lecture 11.