ME415: Computational Fluid Dynamics & Heat Transfer **Roll no. 13D100026**

Assignment # 2: 2D Computational Heat Advection & Convection for Cartesian Geometry

Problem # 1: Flux based solution methodology, with explicit method and uniform grid:

a) Plot and discuss the steady state temperature contours for the different advection schemes (3 figures).
b) Plot and discuss the temperature profile at the vertical centerline(*x=0.5*), *T(y)*, for the different advection schemes (3 figures).

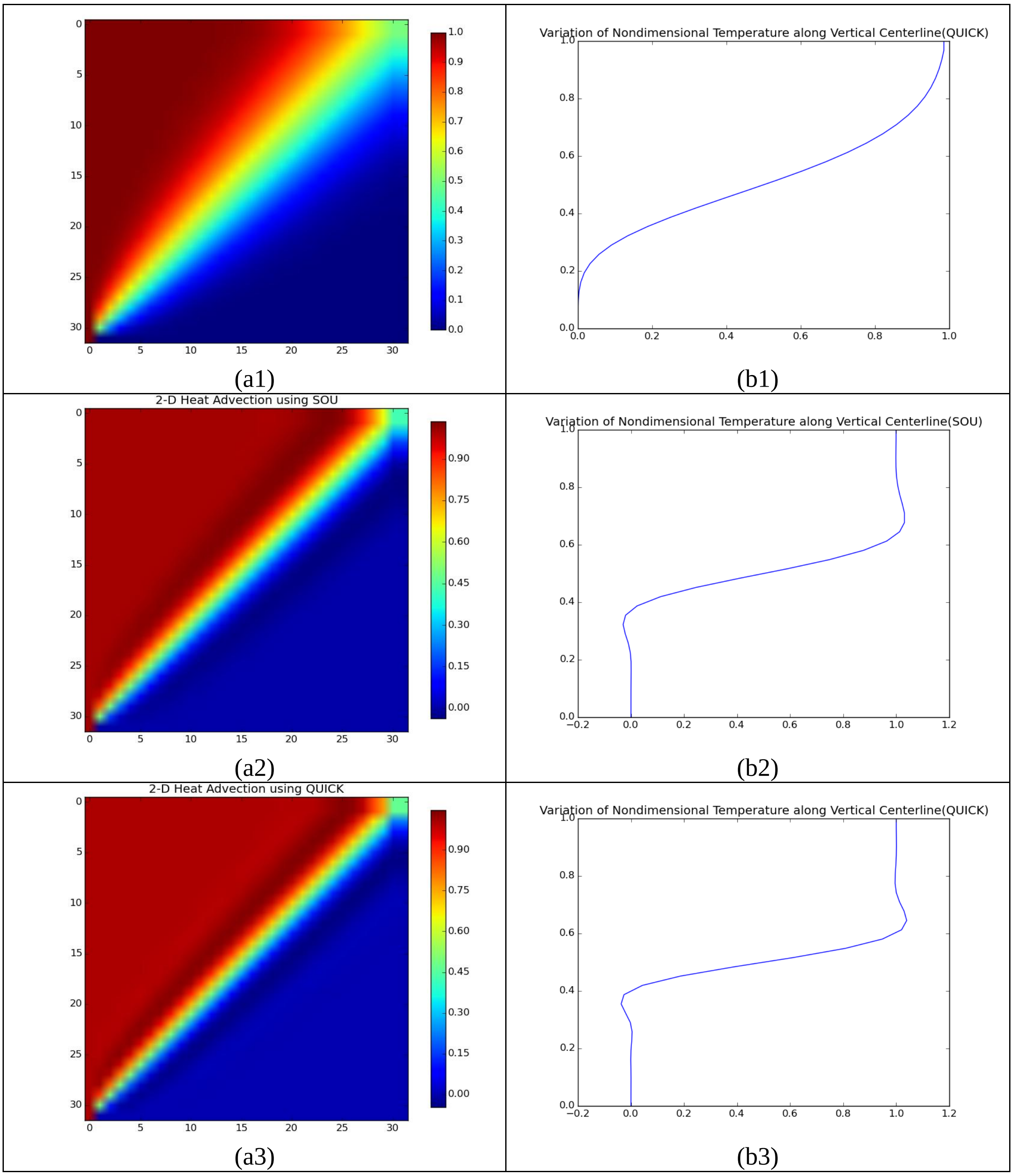
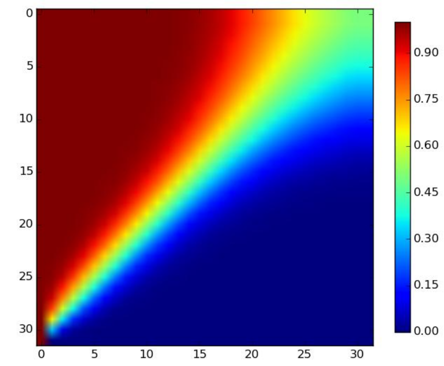


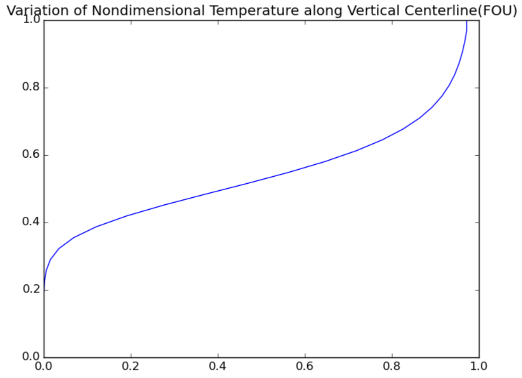
Fig. 2.1: Steady state temperature contours using the (a1) FOU scheme (a2) SOU scheme (a3) QUICK scheme. Temperature variation along the vertical centerline using the (b1) FOU scheme (b2) SOU scheme (b3) QUICK scheme

Discussion on the Fig. 2.1: Write your answer, limited inside this text box only
Temperature at centreline varies from 0°C at bottom, remains constant upto some distance, and then changes to 100°C.
As can be seen from part (a), Due to advection, contour lines at steady state are spread-out more in case of FOU than QUICK and SOU. Exact Solution would be when no Spread is there at the diagonal. Thus QUICK gives better solution than both SOU and FOU.
From both Temperature Contour and Temperature profile at centre line, it can be seen that while Temperatures by FOU remain within limits (0°C-100°C), Temperatures by SOU and QUICK schemes exceed the temperature limits at certain points indicated by dark red regions in Temperature Contour plot.

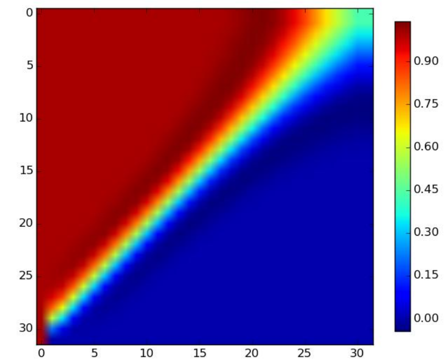
Problem # 2: Coefficient of LAEs based solution methodology, with implicit method and non-uniform grid:



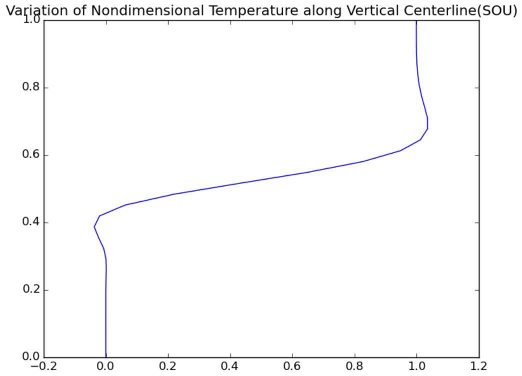
(a1)



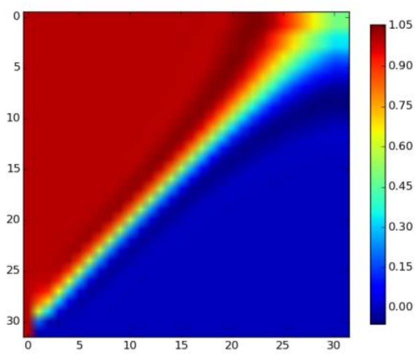
(b1)



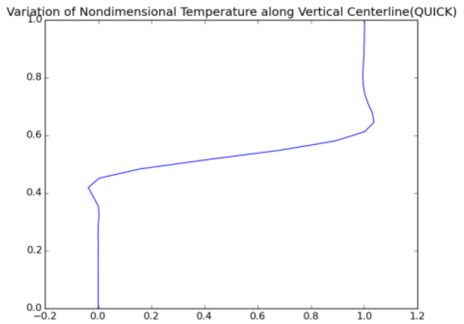
(a2)



(b2)



(a3)



(b3)

Discussion on the Fig. 2.2: Write your answer, limited inside this text box only
Temperature at centreline varies from 0°C at bottom, remains constant upto some distance, and then changes to 100°C. On comparing, we can conclude that implicit method is more accurate since it gives less errors reason being the iterations are carried out over Temperature at that instant only unlike explicit method where iterations are carried out over previous iteration's Temperature.
As can be seen from part (a), Due to advection, contour lines at steady state are spread-out more in case of FOU than QUICK and SOU. Exact Solution would be when no Spread is there at the diagonal. Thus QUICK gives better solution than both SOU and FOU.
From both Temperature Contour and Temperature profile at centre line, it can be seen that while Temperatures by FOU and SOU remain within limits (0°C-100°C), Temperatures by QUICK schemes exceed the temperature limits at certain points indicated by dark red regions in Temperature Contour plot.

Problem # 3: Flux based solution methodology, with explicit method and uniform grid:

a) Plot and discuss the steady state temperature contours for the different advection schemes (2 figures).

b) Plot and discuss the temperature profile, *T(y)*, at different axial locations (x/L=0.2, 0.4, 0.6, 0.8 and 1), for the different advection schemes (2 figures).

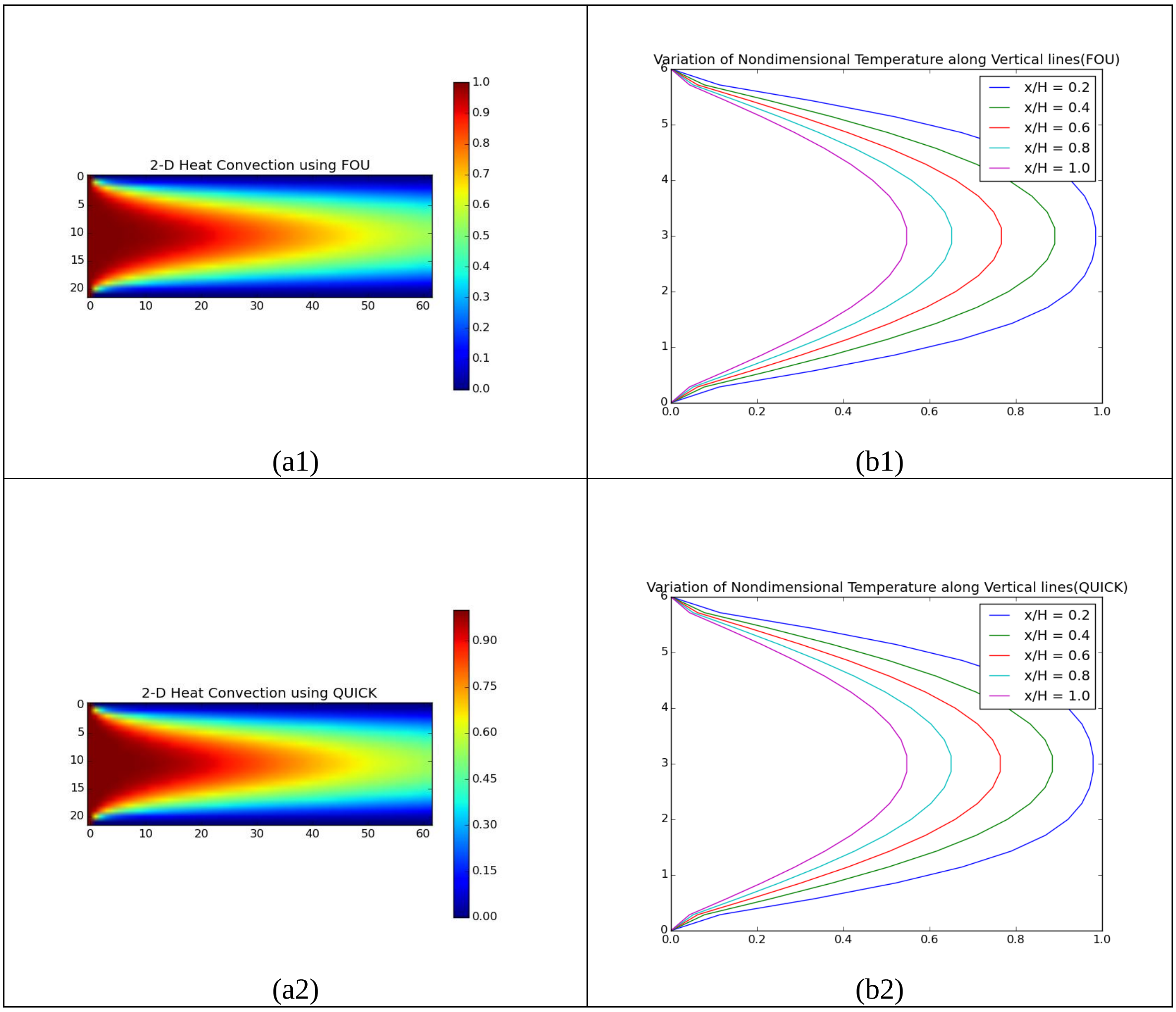


Fig. 2.3: Steady state temperature contours using the (a1) FOU scheme and (a2) QUICK scheme.
Temperature profiles using the (b1) FOU scheme and (b2) QUICK scheme

Discussion on the Fig. 2.3: Write your answer, limited inside this text box only
From both FOU and Quick Schemes contours, it can be concluded that Temperature of fluid decreases in the direction of flow. Since the entering fluid is at higher temperature than the walls of the channel, thus it will lose energy by conduction and advection both, thus decreasing temperature as the fluid flows.
The shapes of temperature contour at various locations remain same for both FOU and QUICK. However, the decrease is more in case of contours obtained from QUICK advection scheme than in case of FOU. This is because QUICK is a higher order scheme and thus more accurate.
It can also be concluded that maximum temperature occurs at the centre of the channel, decreasing in both directions(vertical).
Temperature boundary layer is also visible in both temperature contours, where the temperature remains constant. The width of the temperature boundary layer increases with increasing distance.

Problem # 4: Coefficient of LAEs based solution methodology, with implicit method and non-uniform grid:

a) Plot and discuss the steady state temperature contours for the different advection schemes (2 figures).

b) Plot and discuss the temperature profile, *T(y)*, at different axial locations (x/L=0.2, 0.4, 0.6, 0.8 and 1), for the different advection schemes (2 figures).

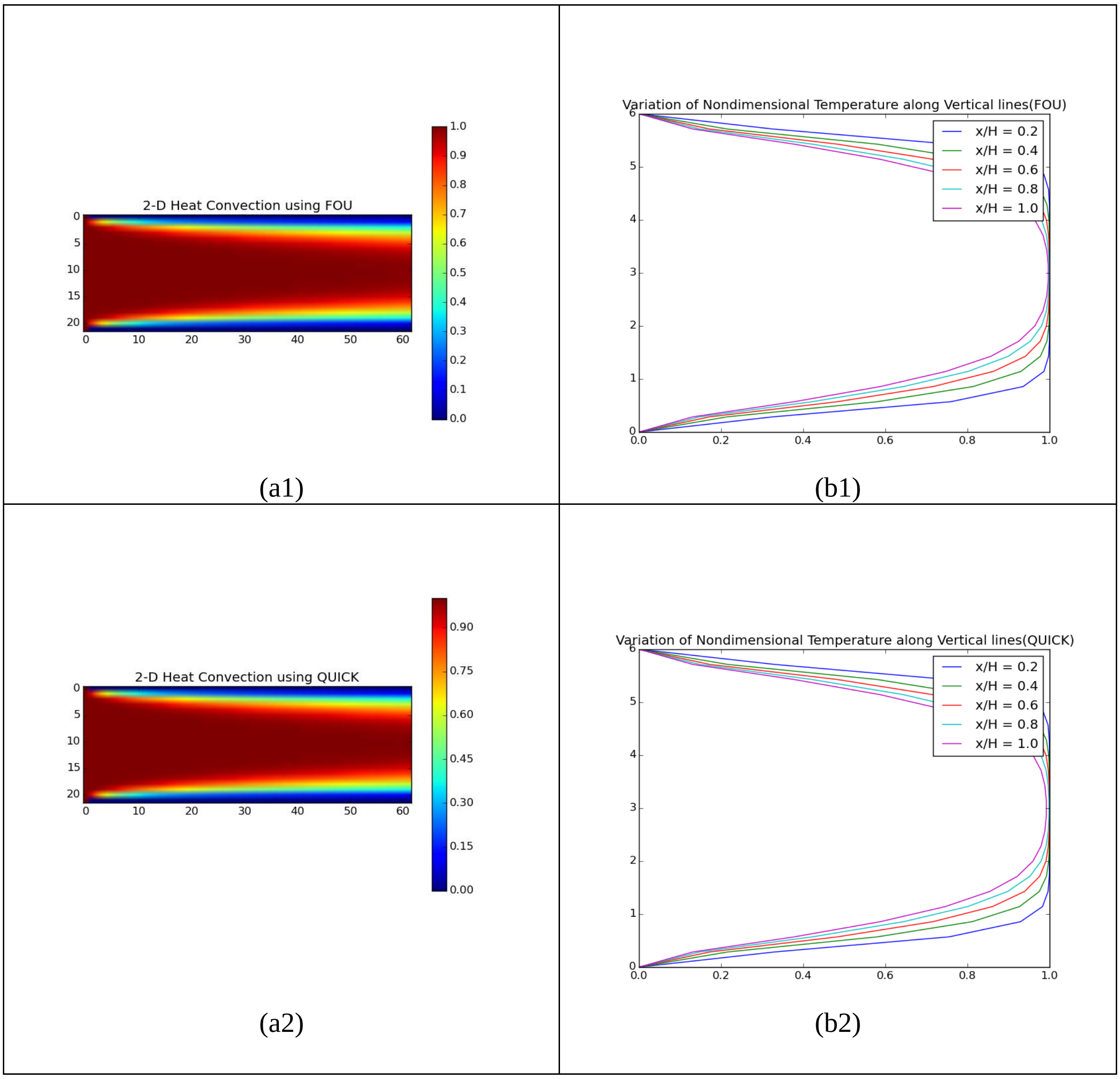


Fig. 2.4: Steady state temperature contours using the (a1) FOU scheme and (a2) QUICK scheme. Temperature profiles using the (b1) FOU scheme and (b2) QUICK scheme

Discussion on the Fig. 2.4: Write your answer, limited inside this text box only
From both FOU and Quick Schemes contours, it can be concluded that Temperature of fluid decreases in the direction of flow. Since the entering fluid is at higher temperature than the walls of the channel, thus it will lose energy by conduction and advection both, thus decreasing temperature as the fluid flows.
On comparing, we can conclude that implicit method is more accurate since it gives less errors reason being the iterations are carried out over Temperature at that instant only unlike explicit method where iterations are carried out over previous iteration's Temperature. Thus, rate of convergence is more in case of Implicit method than Flux-Based Method.
The shapes of temperature contour at various locations remain same for both FOU and QUICK. However, the decrease is more in case of contours obtained from QUICK advection scheme than in case of FOU.
This is because QUICK is a higher order scheme and thus more accurate.
It can also be concluded that maximum temperature occurs at the centre of the channel, decreasing in both directions(vertical).
Temperature boundary layer is also visible in both temperature contours, where the temperature remains constant. The width of the temperature boundary layer increases with increasing distance.