**1.** Text, 5.2

**2.** This variation of text, 5.3. This problems concerns the wave equation $u_{tt} = c^2 u_{xx}$ with initial data $u(x,0)$ and $u_t(x,0)$.

a) Use the one-sided $O(h^2)$ approximation for the first derivative from Table 1.1 on page 7 to derive an approximation for $u_t(x,0)$.

b) The approximation you just wrote down involves values of $u$ at timesteps $t_0$, $t_1$ and $t_2$. The centered difference strategy for the wave equation also yields an equation involving values of $u$ at timesteps $t_0$, $t_1$ and $t_2$. Combine these two equations together to eliminate the values at $t_1$ to get an equation that relates values at $t_2$ to values at $t_0$.

c) Explain why the numerical scheme you just wrote down does not satisfy the CFL condition.

d) Instead, introduce an $O(h^2)$ approximation for the initial condition by introducing the (unknown) value of $u$ at $t_{-1}$. This is a so-called ghost point.

e) Combine the equation you just derived together with the centered difference strategy for the wave equation to obtain a technique for computing an approximation of $u$ at $t_1$ from initial conditions.

f) Show that the equation you just derived satisfies the CFL condition.

**3.** Text, 5.6