1) SHOW THAT

$$\underbrace{\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right)\psi = \frac{1}{r}\frac{\partial^2}{\partial r^2}(r\psi)}$$

STARTING WITH THE LHS

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right) = \frac{1}{r^2}\left[2r\frac{\partial\psi}{\partial r} + r^2\frac{\partial^2\psi}{\partial r^2}\right]$$

$$= \frac{1}{r}\left[2\frac{\partial\psi}{\partial r} + r\frac{\partial^2\psi}{\partial r^2}\right] \qquad (1)$$

NOW FOR THE RHS

$$\frac{1}{r}\frac{\partial^2}{\partial r^2}(r\psi) = \frac{1}{r}\frac{\partial}{\partial r}\left[\psi + r\frac{\partial\psi}{\partial r}\right]$$

$$= \frac{1}{r}\left[\frac{\partial\psi}{\partial r} + \left(\frac{\partial\psi}{\partial r} + r\frac{\partial^2\psi}{\partial r^2}\right)\right]$$

$$= \frac{1}{r}\left[2\frac{\partial\psi}{\partial r} + r\frac{\partial^2\psi}{\partial r^2}\right] \qquad (2)$$

SINCE THE RIGHT-HAND SIDES OF (1) & (2) ARE IDENTICAL, THEIR LEFT-HAND SIDES MUST BE EQUAL, GIVING

$$\boxed{\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right)\psi = \frac{1}{r}\frac{\partial^2}{\partial r^2}(r\psi)} \quad \text{QED!}$$

NOTA BENE: TOWNSEND SUBSTITUTES THE RHS OF THIS FOR THE LHS IN WRITING (6.63) AFTER (6.62)