Q- Electrons with a speed of 2.5×10^6 m/s pass through a double-slit apparatus. Interference fringes are detected with a fringe spacing of 1.6 mm.

(a) What will the fringe spacing be if the electrons are replaced by neutrons with the same speed?

The wave length associated with the motion of electron is given by

$$\lambda_e = \frac{h}{m_e v}$$

Now as we know that the fringe spacing b in a double slit experiment for wave of wavelength λ is given by

$$\beta = \frac{D\lambda}{d}$$

Here D is the distance of screen from the sources and d is the source spacing.

Hence the fringe width for the electrons is given by

$$\beta_e = \frac{D * h}{d * m_e * v} \qquad \text{------------------------------------ (1)}$$

And similarly, the fringe width for neutrons in the same experiment with the same speed is given by

$$\beta_n = \frac{D * h}{d * m_n * v} \qquad \text{------------------------------------ (2)}$$

Dividing the equation (2) by equation (1) we get

$$\frac{\beta_n}{\beta_e} = \frac{m_e}{m_n}$$

Gives $\beta_n = \frac{m_e}{m_n}\beta_e = \frac{9.11 * 10^{-31}}{1.67 * 10^{-27}} * 1.6 = 8.73 * 10^{-4}\ mm$ = **0.873 μm**

(b) What speed must neutrons have to produce interference fringes with a fringe spacing of 1.6 mm?

If the speeds of the electrons and the neutrons are different in such a way that the fringe spacing is the same then equating equation (1) and (2) we get

$$\beta = \frac{D * h}{d * m_e * v_e} = \frac{D * h}{d * m_n * v_n}$$

Gives $v_n = \frac{m_e * v_e}{m_n} = \frac{9.11 * 10^{-31}}{1.67 * 10^{-27}} * 2.5 * 10^6 = 1.36 * 10^3\ m/s$

$1.36*10^3$ m/s