(ii) $\text{K.E.}_{\text{before}} = \frac{1}{2}mu^2$ J

$$\text{K.E.}_{\text{after}} = \frac{1}{2}m\left[p^2 + \left(\frac{u\sqrt{3}}{2}\right)^2\right] + \frac{1}{2}mq^2$$

$$= \frac{1}{2}m\left[\frac{u^2}{16}(1 - e)^2 + \frac{3u^2}{4}\right]$$

$$+ \frac{1}{2}m\left[\frac{u^2}{16}(1 + e)^2\right] \text{ ...let } e = 0$$

$$= \left[\frac{1}{2}m\frac{u^2}{16} + \frac{3u^2}{4} + \frac{u^2}{16}\right]$$

$$= \frac{1}{2}m\left(\frac{7u^2}{8}\right)$$

$$= \frac{7mu^2}{16} \text{ J}$$

$$\text{Loss} = \frac{mu^2}{2} - \frac{7mu^2}{16} = \frac{mu^2}{16} \text{ J}$$

$$\Rightarrow \%\text{ loss} = \frac{\frac{1}{16}mu^2}{\frac{1}{2}mu^2} \times 100 = 12\frac{1}{2}\%$$

(iii) $$\text{K.E.}_{A(\text{after})} = \frac{1}{2}m\left[p^2 + \left(\frac{u\sqrt{3}}{2}\right)^2\right]$$

$$= \frac{1}{2}m\left[\frac{u^2}{16}(1 - e)^2 + \frac{3u^2}{4}\right]$$

$$= \frac{1}{2}m\left[\frac{u^2}{16}(1 - 2e + e^2) + \frac{3u^2}{4}\right]$$

$$= \frac{1}{2}m\left[\frac{13u^2}{16} - \frac{2eu^2}{16} + \frac{e^2u^2}{16}\right]$$

$$= \frac{mu^2}{32}[13 - 2e + e^2]$$

$$\text{K.E.}_{B(\text{after})} = \frac{1}{2}mq^2 = \frac{1}{2}m\left[\frac{u^2}{16}(1 + e)^2\right]$$

$$= \frac{mu^2}{32}(1 + 2e + e^2)$$

$$\frac{\text{K.E.}_{A(\text{after})}}{\text{K.E.}_{B(\text{after})}} = \frac{7}{1}$$

$$\Rightarrow \frac{13 - 2e + e^2}{1 + 2e + e^2} = 7$$

$$\Rightarrow 13 - 2e + e^2 = 7 + 14e + 7e^2$$

$$\Rightarrow 6e^2 + 16e - 6 = 0$$

$$\Rightarrow 3e^2 + 8e - 3 = 0$$

$$\Rightarrow (3e - 1)(e + 3) = 0$$

$$\Rightarrow e = \frac{1}{3} \quad 0 \leqslant e \leqslant 1$$

Q. 5. (i)

Before	**(Mass)**	**After**
A: $p\vec{i} + q\vec{j}$	m	$r\vec{i} + q\vec{j}$
B: $0\vec{i} + 0\vec{j}$	$2m$	$t\vec{i} + 0\vec{j}$

$$\tan\theta = \frac{q}{p}$$

$$\frac{q}{p} \times \frac{q}{r} = -1 \quad \text{... new path at right angles to old path}$$

$$\Rightarrow \frac{q^2}{pr} = -1$$

$$\Rightarrow r = -\frac{q^2}{p}$$

Also, $\sqrt{r^2 + q^2} = 0.2$

$$\Rightarrow r^2 + q^2 = 0.04$$

$$\Rightarrow \frac{q^4}{p^2} + q^2 = 0.04$$

$$\Rightarrow \frac{q^4 + p^2q^2}{p^2} = 0.04$$

$$\Rightarrow \frac{q^2(p^2 + q^2)}{p^2} = 0.04 \text{ ... } \sqrt{p^2 + q^2} = 0.06$$

so, $p^2 + q^2 = 0.36$

$$\Rightarrow \frac{0.36q^2}{p^2} = 0.04 \quad \text{... divide by 0.04}$$

$$\Rightarrow \frac{9q^2}{p^2} = 1$$

$$\Rightarrow \frac{q^2}{p^2} = \frac{1}{9}$$

$$\Rightarrow \frac{q}{p} = \frac{1}{3} = \tan\theta$$

(ii) Momentum in the $\vec{i}$–direction is conserved

$m(p) + 2m(0) = m(r) + 2m(t)$

...divide by m

$$\Rightarrow r + 2t = p$$

$$\Rightarrow t = \frac{p - r}{2} \quad \textbf{Equation 1}$$

N.E.L.

$$\frac{r - t}{p - 0} = -e$$

$$\Rightarrow r - t = -pe \quad \textbf{Equation 2}$$

$$\Rightarrow r - \frac{p - r}{2} = -pe$$

$$\Rightarrow 2r - p + r = -2pe$$

$$\Rightarrow 3r - p = -2pe$$