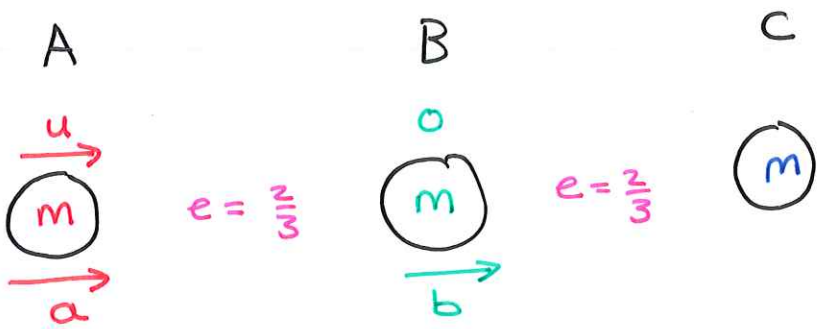
Q1.



(a)

Com $\quad um = ma + mb$

$$u = a + b$$

e

$$\frac{2}{3} = \frac{b-a}{u}$$

$$2u = 3b - 3a$$

Solve for a

$$b = u - a$$

sub

$$2u = 3(u-a) - 3a$$

$$2u = 3u - 3a - 3a$$

$$6a = u$$

$$a = \frac{u}{6}$$

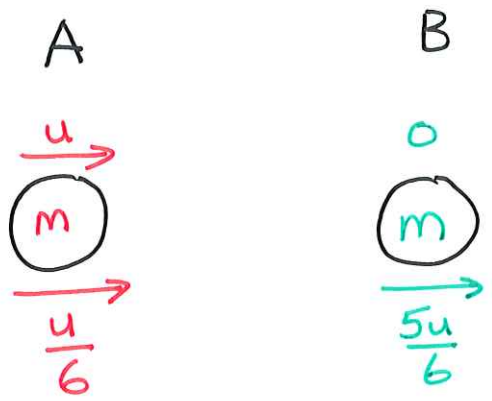
$$b = u - a$$

$$b = u - \frac{u}{6}$$

$$b = \frac{5u}{6}$$

Q1

(b)



KE Before

$$\frac{1}{2}(m)(u)^2 + \frac{1}{2}(m)(0)^2$$

$$= \frac{mu^2}{2}$$

KE After

$$\frac{1}{2}(m)\left(\frac{u}{6}\right)^2 + \frac{1}{2}(m)\left(\frac{5u}{6}\right)^2$$

$$= \frac{mu^2}{72} + \frac{25mu^2}{72}$$

$$= \frac{26mu^2}{72}$$

KE LOSS

$$\text{KE LOSS} = \frac{mu^2}{2} - \frac{26mu^2}{72}$$

$$= \frac{5mu^2}{36}$$

Q2.

(a)

Com

$$4mu + 3mu = 2mp + 3mq$$

$$7u = 2p + 3q$$

e

$$\frac{1}{2} = \frac{q - p}{2u - u}$$

$$u = 2q - 2p$$

Solve for q

$$2p = 2q - u$$

sub

$$7u = 2q - u + 3q$$

$$8u = 5q$$

$$q = \frac{8u}{5}$$

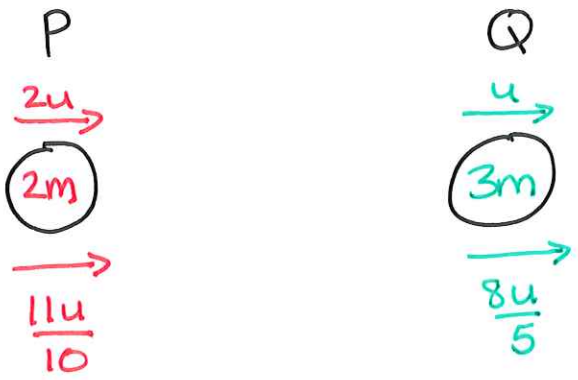
$$p = q - \frac{1}{2}u$$

$$p = \frac{8u}{5} - \frac{u}{2}$$

$$p = \frac{11u}{10}$$

Q2.

(b)



KE Before

$$\frac{1}{2}(2m)(2u)^2 + \frac{1}{2}(3m)(u)^2$$

$$= 4mu^2 + \frac{3mu^2}{2}$$

$$= \frac{11mu^2}{2}$$

KE After

$$\frac{1}{2}(2m)\left(\frac{11u}{10}\right)^2 + \frac{1}{2}(3m)\left(\frac{8u}{5}\right)^2$$

$$= \frac{121mu^2}{100} + \frac{96mu^2}{25}$$

$$= \frac{101mu^2}{20}$$

KE LOSS

$$\frac{11mu^2}{2} - \frac{101mu^2}{20} = \frac{9mu^2}{20}$$

Q3.

(a)

Com

$$12um + 6um = 4ma + 12emu$$

$$18u = 4a + 12eu$$

e

$$e = \frac{4eu - a}{3u - 2u}$$

$$4eu - a = eu$$

$$3eu = a$$

Solve for e

$$18u = 4a + 12eu$$

sub

$$18u = 4(3eu) + 12eu$$

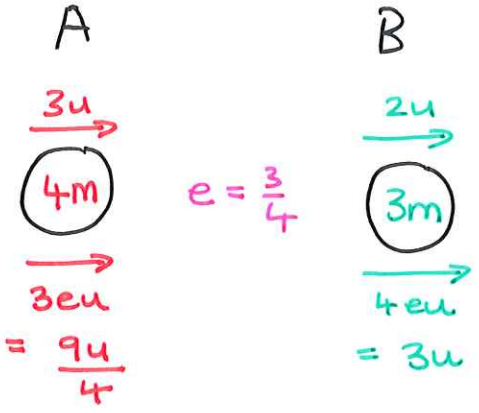
$$18u = 24eu$$

$$e = \frac{18}{24}$$

$$e = \frac{3}{4}$$

Q3.

(b)



KE Before

$$\frac{1}{2}(4m)(3u)^2 + \frac{1}{2}(3m)(2u)^2$$

$$= 18mu^2 + 6mu^2$$

$$= 24mu^2$$

KE After

$$\frac{1}{2}(4m)\left(\frac{9u}{4}\right)^2 + \frac{1}{2}(3m)(3u)^2$$

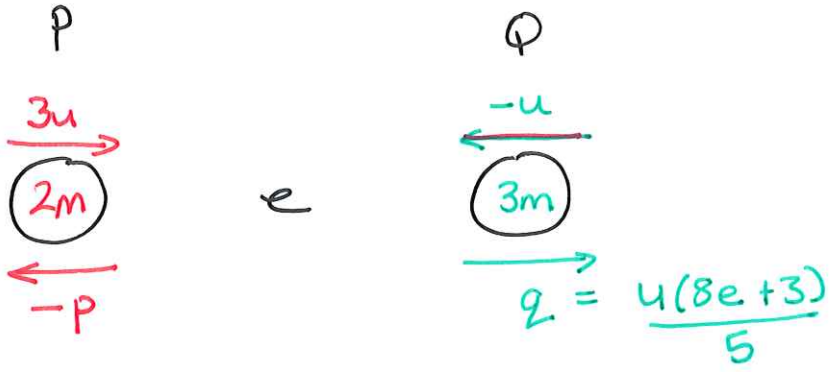
$$= \frac{162mu^2}{16} + \frac{27mu^2}{2} = \frac{189mu^2}{8}$$

KE LOSS

$$24mu^2 - \frac{189mu^2}{8}$$

$$= \frac{3mu^2}{8}$$

Q4.



(a)

e

$$e = \frac{q - -p}{3u - -u}$$

$$4eu = q + p$$

sub

$$4eu = \frac{u(8e+3)}{5} + p$$

$$4eu = \frac{8ue}{5} + \frac{3u}{5} + p$$

$$\frac{12eu}{5} - \frac{3u}{5} = p$$

$$\frac{3u}{5}(4e-1) = p$$

$-\left(\frac{3u}{5}(4e-1)\right)$

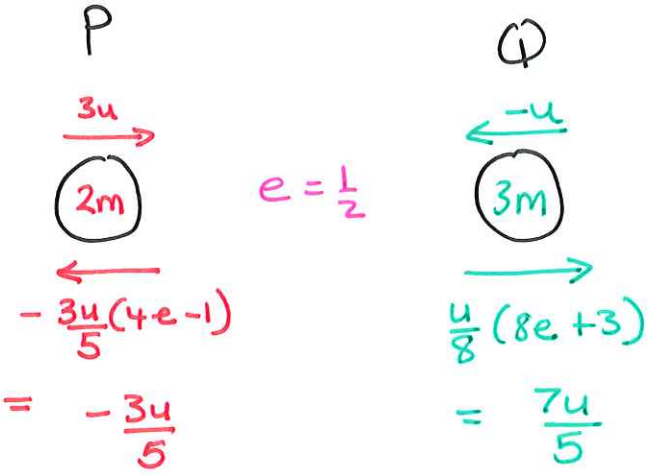
$$4e-1 > 0$$

$$4e > 1$$

$$e > \frac{1}{4}$$

$$\frac{1}{4} < e \leq 1$$

Q4.
(b)



KE Before = T

$$\frac{1}{2}(2m)(3u)^2 + \frac{1}{2}(3m)(-u)^2 = T$$

$$9um^2 + \frac{3}{2}mu^2 = T$$

$$\frac{21mu^2}{2} = T$$

KE After = kT

$$\frac{1}{2}(2m)\left(-\frac{3u}{5}\right)^2 + \frac{1}{2}(3m)\left(\frac{7u}{5}\right)^2 = kT$$

$$\frac{9mu^2}{25} + \frac{147mu^2}{50} = kT$$

$$\frac{165mu^2}{50} = kT$$

sub

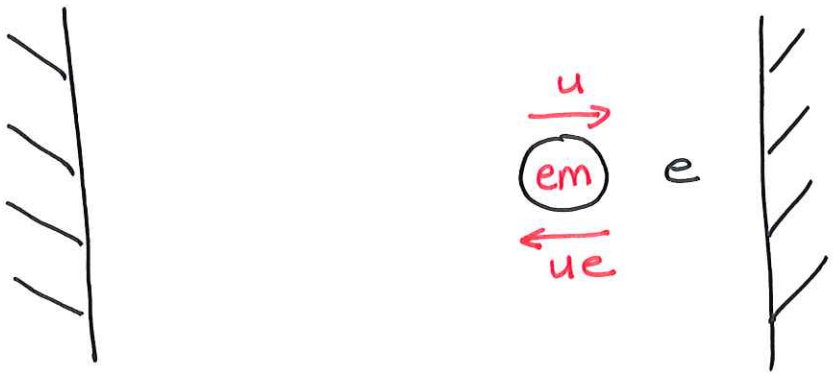
$$\frac{165mu^2}{50} = k\left(\frac{21mu^2}{2}\right)$$

$$\frac{165}{50} = k\frac{21}{2}$$

$$k = \frac{11}{35}$$

Q5

(a)

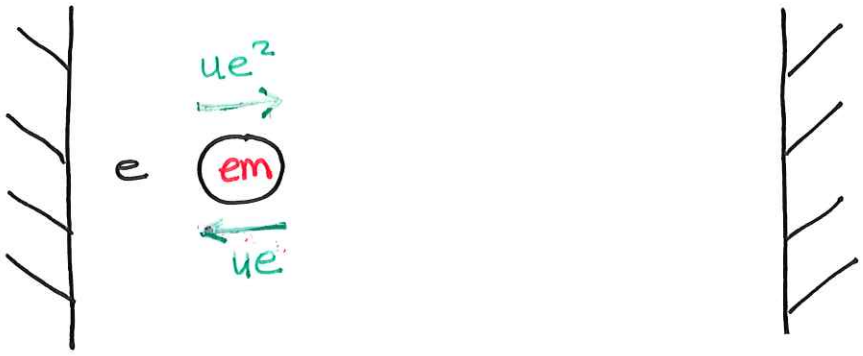


Impact 1

KE Before = $\frac{1}{2}(em)(u)^2$

KE After = $\frac{1}{2}(em)(ue)^2$

KE Loss = $\frac{1}{2}emu^2 - \frac{1}{2}mu^2e^3$



Impact 2

KE Before = $\frac{1}{2}(em)(ue)^2$

KE After = $\frac{1}{2}(em)(ue^2)^2$

KE Loss = $\frac{1}{2}mu^3 - \frac{1}{2}me^5u^2$

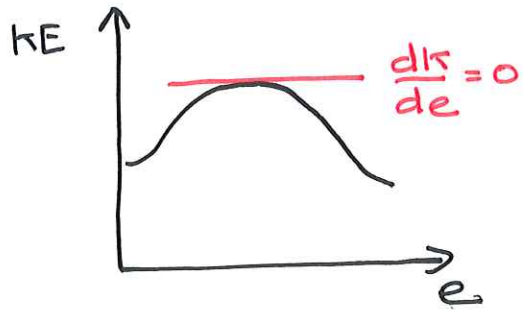
Total KE Loss = $\frac{1}{2}emu^2 - \frac{1}{2}mu^2e^3 + \frac{1}{2}mu^3 - \frac{1}{2}me^5u^2$

$= \frac{emu^2}{2} - \frac{mu^2e^5}{2}$

$= \frac{1}{2}mu^2[e - e^5]$

Q5.

(b) $\text{KE LOSS} = \frac{1}{2}mu^2e - \frac{1}{2}mu^2e^5$



$$\frac{dK}{de} = \frac{1}{2}mu^2e^2 - \frac{5}{2}mu^2e^6$$

$$0 = \frac{1}{2}mu^2e^2\left[1 - 5e^4\right]$$

$$\therefore \quad 1 - 5e^4 = 0$$

$$5e^4 = 1$$

$$e^4 = \frac{1}{5}$$

$$e = \sqrt[4]{\frac{1}{5}} = 0.669 \text{ (3sf)}$$

(c) – Particle will bounce off each wall indefinitely

– The speed of the particle decreases after each collision with the wall.

Q6.

(a)

CoM

$$5ma - 3mb = 5mv + 6mv$$

$$5a - 3b = 11v$$

e

$$e = \frac{2v - v}{a - (-b)}$$

$$v = e(a+b)$$

Solve for a

$$b = \frac{v}{e} - a$$

sub

$$5a - 3\left(\frac{v}{e} - a\right) = 11v$$

$$5a - \frac{3v}{e} + 3a = 11v$$

$$8a = 11 + \frac{3v}{e}$$

$$a = \frac{v}{8}\left(11 + \frac{3}{e}\right)$$

$$b = \frac{v}{e} - \frac{v}{8}\left(11 + \frac{3}{e}\right)$$

$$b = \frac{v}{e} - \frac{11v}{8} - \frac{3v}{e}$$

$$b = \frac{5v}{8e} - \frac{11v}{8}$$

$$b = \frac{v}{8}\left(\frac{5}{e} - 11\right)$$

Q6

(a) $b = \frac{v}{8}\left(\frac{5}{e} - 11\right)$

$b = \frac{v}{8e}(5 - 11e)$

$-b \quad \therefore \; b > 0$

$\therefore \quad 5 - 11e > 0$

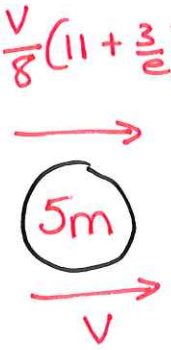
$5 > 11e$

$e < \frac{5}{11}$

$0 < e < \frac{5}{11}$

Q6.

(b)



KE before $= \frac{1}{2}(5m)\left(\frac{v}{8}(11+\frac{3}{e})\right)^2$

KE after $= \frac{1}{2}(5m)(v)^2$

$$\frac{16}{100} \times \frac{5m}{2}\left[\frac{v^2}{64}(11+\frac{3}{e})^2\right] = \frac{5m}{2}v^2$$

$\times \frac{2}{5m}$

$$\frac{16v^2}{6400}(11+\frac{3}{e})^2 = v^2$$

$\div v^2$

$$\frac{16}{6400}(11+\frac{3}{e})^2 = 1$$

$$(11+\frac{3}{e})^2 = 400$$

$$11+\frac{3}{e} = 20$$

$$\frac{3}{e} = 9$$

$$e = \frac{1}{3}$$