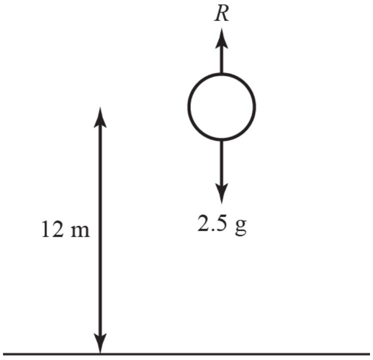
AS Exam-style practice

1 a i



Work done by resistance = initial potential energy – final kinetic energy

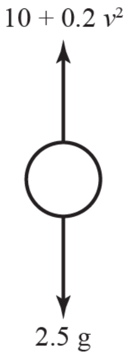
$= 2.5 \times 9.8 \times 12 - \frac{1}{2} \times 2.5 \times 10^2 = 169\,\text{J}$

a ii Work done by resistive force = force × distance

So $160 = R \times 12$

Therefore $R = \frac{169}{12} = 14.1\,\text{N}$

b



When the velocity has reached a maximum, the ball's acceleration will be $0\,\text{m s}^{-2}$

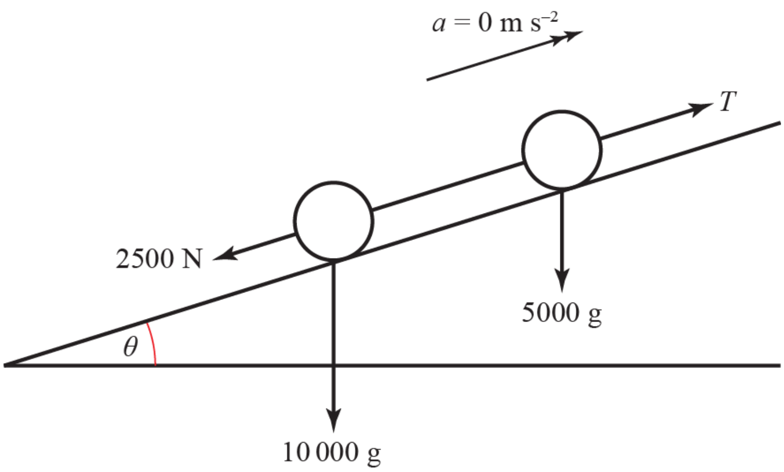
By Newton's 2nd law, the resultant force on the ball will therefore be 0 N.

So $10 + 0.2v^2 = 2.5g$

$\therefore v^2 = \frac{2.5g - 10}{0.2}$

$\therefore v = \sqrt{\frac{2.5g - 10}{0.2}} = 8.51\ \text{m s}^{-1}$

2



Power = 40 kW = 40 000 W

Power $= Tv$

$40000 = Tv$

So $T = \dfrac{40\,000}{v}$

Applying Newton's 2nd Law up the plane for the whole system $(\nearrow)$:

$$T - 5000g\sin\theta - 10000g\sin\theta - 2500 = 0$$

$$\frac{40\,000}{v} - 5000g\sin\theta - 10\,000g\sin\theta - 2500 = 0$$

Now substituting $\sin\theta = \dfrac{1}{50}$ gives:

$$\frac{40\,000}{v} - \frac{5000g}{50} - \frac{10\,000g}{50} - 2500 = 0$$

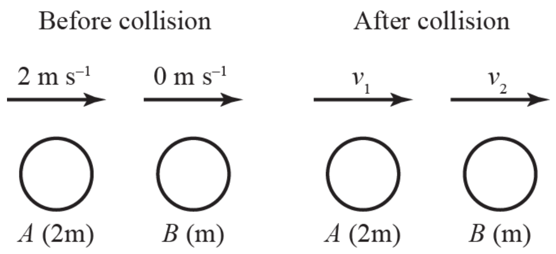
$$\frac{40\,000}{v} - \frac{15\,000g}{50} - 2500 = 0$$

$$\frac{40\,000}{v} - 300g - 2500 = 0$$

$$\frac{40\,000}{v} = 300g + 2500$$

So $v = \dfrac{40\,000}{(300g + 2500)} = 7.35 \text{ m s}^{-1}$

3 a



Using conservation of momentum for the system $(\rightarrow)$:

$2m \times 2 = 2mv_1 + mv_2$

$4m = 2mv_1 + mv_2$

$4 = 2v_1 + v_2$ **(1)**

Newton's law of restitution gives

$\frac{v_2 - v_1}{2-0} = 0.8$

$1.6 = v_2 - v_1$ **(2)**

Eliminating v_2 from equations **(1)** and **(2)** gives

$2.4 = 3v_1$

So $v_1 = \frac{2.4}{3} = 0.8 \text{ m s}^{-1}$

Substituting into equation **(2)** gives

$1.6 = v_2 - 0.8$

So $v_2 = 2.4 \text{ m s}^{-1}$

Both particles move in the direction A was originally travelling in.

b Kinetic energy lost = initial kinetic energy – final kinetic energy

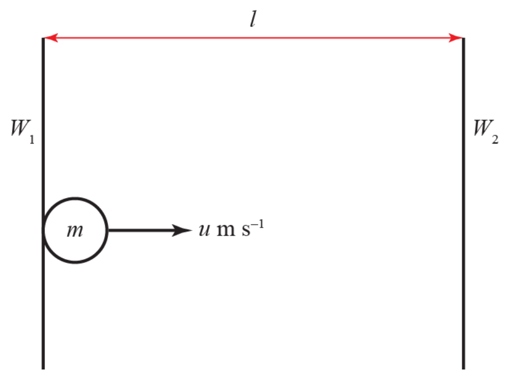
$0.36 = \frac{1}{2} \times (2m) \times 2^2 - \frac{1}{2} \times (2m) \times 0.8^2 - \frac{1}{2} \times m \times 2.4^2$

$0.36 = 4m - 0.64m - 2.88m$

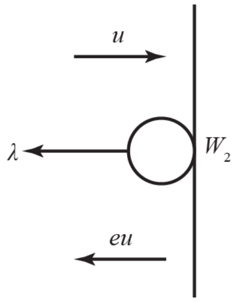
$0.36 = 0.48m$

So $m = \frac{0.36}{0.48} = 0.75 \text{ kg}$

4



a Consider the particle just before and after colliding with wall W_2.
The particle will rebound from W_2 with speed eu.



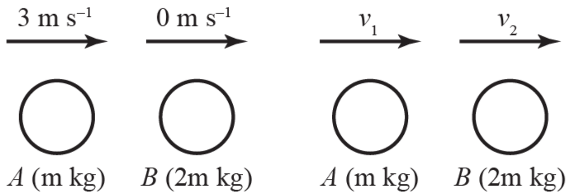
The impulse on the particle = the change in momentum of the particle
So $\lambda = mv - mu$
$\lambda = meu - m(-u)$
$\lambda = meu + mu$
$\lambda = mu(1+e)$, as required.

b The time taken for the particle to travel from $W_1 \to W_2$ is given by $\frac{\text{distance}}{\text{speed}} = \frac{l}{u}$

The time taken for the particle to travel from $W_2 \to W_1$ is given by $\frac{\text{distance}}{\text{speed}} = \frac{l}{eu}$

So the total time taken is $\frac{l}{u} + \frac{l}{eu} = \frac{el+l}{eu} = \frac{l}{eu}(e+1)$

5



Using conservation of momentum for the collision between A and B $(\rightarrow)$:

$3m = mv_1 + 2mv_2$

$3 = v_1 + 2v_2$ **(1)**

Newton's law of restitution gives

$\frac{v_2 - v_1}{3 - 0} = 0.9$

$2.7 = v_2 - v_1$ **(2)**

Eliminating v_1 from equations **(1)** and **(2)** gives

$5.7 = 3v_2$

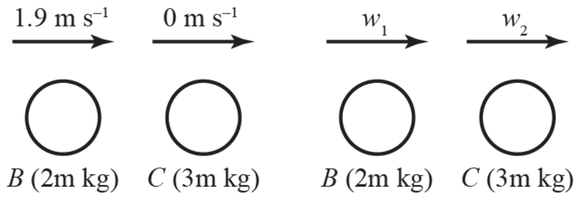
So $v_2 = \frac{5.7}{3} = 1.9 \text{ m s}^{-1}$

Substituting into equation **(2)** gives

$2.7 = 1.9 - v_1$

So $v_1 = 1.9 - 2.7 = -0.8 \text{ m s}^{-1}$

Now consider the second collision, i.e. between B and C:



Using conservation of momentum for the collision between B and C $(\rightarrow)$:

$3.8m = 2mw_1 + 3mw_2$

$3.8 = 2w_1 + 3w_2$ **(3)**

Newton's law of restitution gives

$\frac{w_2 - w_1}{1.9 - 0} = 0.9$

$w_2 - w_1 = 1.71$

or $2w_2 - 2w_1 = 3.42$ **(4)**

Adding equations **(3)** and **(4)** gives

$7.22 = 5w_2$

So $w_2 = \frac{7.22}{5} = 1.444 \text{ m s}^{-1}$

Substituting into equation **(4)** gives

$2w_1 = 2.888 - 3.42$

$2w_1 = -0.532$

So $w_1 = -\frac{0.532}{2} = -0.2666 \text{ m s}^{-1}$

Since $v_1 < w_1 < w_2$, there will be no further collisions.