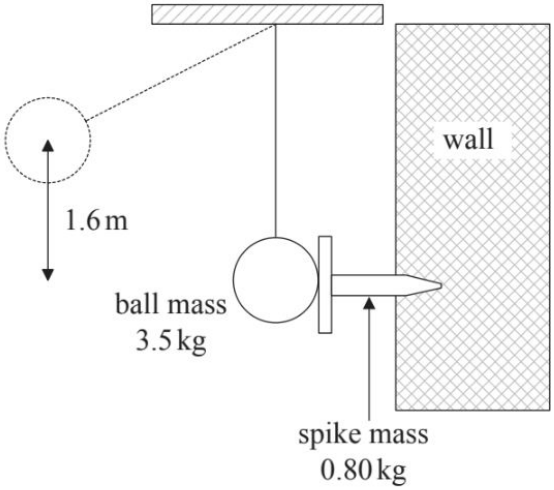
(Question B3, part 1 continued)

(c) A large swinging ball is used to drive a horizontal iron spike into a vertical wall. The centre of the ball falls through a vertical height of 1.6 m before striking the spike in the position shown.



The mass of the ball is 3.5 kg and the mass of the spike is 0.80 kg. Immediately after striking the spike, the ball and spike move together. Show that the

The mass of the ball is 3.5 kg and the mass of the spike is 0.80 kg. Immediately after striking the spike, the ball and spike move together. Show that the

(i) speed of the ball on striking the spike is 5.6 m s^{-1}. *[1]*

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(ii) energy dissipated as a result of the collision is about 10 J. *[4]*

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(Question B3, part 1 continued)

(d) As a result of the ball striking the spike, the spike is driven a distance 7.3×10^{-2} m into the wall. Calculate, assuming it to be constant, the friction force F between the spike and wall. *[3]*

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(e) The machine that is used to raise the ball has a useful power output of 18 W. Calculate how long it takes for the machine to raise the ball through a height of 1.6 m. *[3]*

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(c) (i) $v = \sqrt{2 \times 9.8 \times 1.6}$;

$= 5.6\,\text{m s}^{-1}$ ***[1]***

(ii) calculation of speed of ball and spike $3.5 \times 5.6 = 4.3\,\text{V}$;

$V = \left(\dfrac{3.5 \times 5.6}{4.3} = \right) 4.6\,\text{m s}^{-1}$;

KE before $= \frac{1}{2}\left[3.5 \times 5.6^2 \right]$ KE after $= \frac{1}{2}\left[4.3 \times 4.56^2 \right]$;

energy dissipated $= 54.88 - 44.70$;

$= 10\,\text{J}$ ***[4]***

Accept 9.4 J if 4.6 used for V.

(d) $F = \dfrac{\Delta KE}{s}$;

$\Delta KE = 0.50 \times 4.3 \times 4.6^2 = 45\,(\text{J})$;

$F = \left(\dfrac{45}{7.3 \times 10^{-2}} = \right) 6.2 \times 10^2\,\text{N}$; ***[3]***

or

$a = \dfrac{v^2}{2s}$;

$a = 1.45 \times 10^2\ \text{m s}^{-2}$;

$F = ma = 4.3 \times 1.45 \times 10^2 = 6.2 \times 10^2\,\text{N}$;

(e) $\text{time} = \dfrac{\text{work}}{\text{power}}$;

$\text{work} = (3.5 \times 1.6 \times 9.8 =)\ 55\,(\text{J})$;

$\text{time} = \left(\dfrac{55}{18} = \right) 3.1\,\text{s}$; ***[3]***