PART II

marks

Question 12

(*a*) In the absence of a net external torque, the total angular momentum of a system is conserved. 2

(*b*) Using subscript 1 for quantities in the first situation, and subscript 2 for those in the second,

$$I_2\omega_2 = I_1\omega_1 \qquad 1$$

where $I = \sum_i m_i r_i^2$. 1

Since m is constant and $r_2 = r_1/2$ for each mass,

$$I_2 = I_1/4. \qquad 1$$

Therefore $$\omega_2 = \frac{I_1\omega_1}{I_1/4} = 4\omega_1 = 12 \text{ radians per second.} \qquad 2$$

(Note that the values of the masses are not actually needed, although you could have used them to calculate numerical values for I_1 and I_2 instead of doing the above algebraic manipulation.)

Total for Q12: 7

Question 13

(*a*) Simple harmonic motion is a periodic oscillation in which the displacement from the equilibrium position varies sinusoidally with time. It arises when the restoring force F_x is proportional to the displacement x from the equilibrium position. 1 1

(*b*) Let the spring have force constant k, natural length l_0 and equilibrium length l when extended by the mass.

$$F_x = -kx,$$

i.e. $$mg = k(l - l_0)$$

and $$k = mg/(l - l_0). \qquad 2$$

The period of the oscillation is given by

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{(l-l_0)}{g}} \qquad 1$$

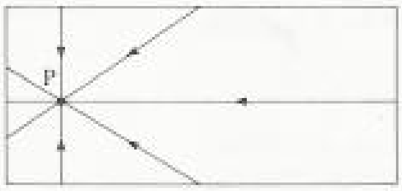
$$= 2\pi\sqrt{\frac{0.25\,\text{m}}{9.8\,\text{m s}^{-2}}}$$

$$= 1.0\,\text{s}. \qquad 2$$

Total for Q13: 7

Question 14

(*a*)



Marks are awarded for:

lines radial 1

arrows towards P 1

Figure 1

(*b*) $$\Delta E_{\text{el}} = q\,\Delta V \qquad 1$$

$$= q(V_{\text{final}} - V_{\text{initial}})$$

$$= q(V_{\text{B}} - V_{\text{A}}) \qquad 1$$

$$= +e\,(-20 - (-10)) \text{ volts}$$

$$= 1.6 \times 10^{-19}\,\text{C} \times (-10\,\text{V})$$

$$= -1.6 \times 10^{-18}\,\text{J}. \qquad 1$$

The energy change is negative because a positive charge accelerates in the direction of the field (e.g. A $\rightarrow$ B), so losing electrostatic potential energy. 1

Total for Q14: 6