1 A car of mass 700 kg is travelling along a straight horizontal road. The resistance to motion is constant and equal to 600 N.

(i) Find the driving force of the car’s engine at an instant when the acceleration is 2 m s\(^{-2}\). \[2\]

(ii) Given that the car’s speed at this instant is 15 m s\(^{-1}\), find the rate at which the car’s engine is working. \[2\]

2 A load of mass 1250 kg is raised by a crane from rest on horizontal ground, to rest at a height of 1.54 m above the ground. The work done against the resistance to motion is 5750 J.

(i) Find the work done by the crane. \[3\]

(ii) Assuming the power output of the crane is constant and equal to 1.25 kW, find the time taken to raise the load. \[2\]

3 A small smooth ring \(R\) of weight 8.5 N is threaded on a light inextensible string. The ends of the string are attached to fixed points \(A\) and \(B\), with \(A\) vertically above \(B\). A horizontal force of magnitude 15.5 N acts on \(R\) so that the ring is in equilibrium with angle \(ARB = 90^\circ\). The part \(AR\) of the string makes an angle \(\theta\) with the horizontal and the part \(BR\) makes an angle \(\theta\) with the vertical (see diagram). The tension in the string is \(T\) N. Show that \(T \sin \theta = 12\) and \(T \cos \theta = 3.5\) and hence find \(\theta\). \[6\]

4 A block of mass 11 kg is at rest on a rough plane inclined at 30° to the horizontal. A force acts on the block in a direction up the plane parallel to a line of greatest slope. When the magnitude of the force is 2\(X\) N the block is on the point of sliding down the plane, and when the magnitude of the force is 9\(X\) N the block is on the point of sliding up the plane. Find

(i) the value of \(X\), \[3\]

(ii) the coefficient of friction between the block and the plane. \[4\]
5 A train starts from rest at a station A and travels in a straight line to station B, where it comes to rest. The train moves with constant acceleration 0.025 m s\(^{-2}\) for the first 600 s, with constant speed for the next 2600 s, and finally with constant deceleration 0.0375 m s\(^{-2}\).

(i) Find the total time taken for the train to travel from A to B. [4]

(ii) Sketch the velocity-time graph for the journey and find the distance AB. [3]

(iii) The speed of the train \(t\) seconds after leaving A is 7.5 m s\(^{-1}\). State the possible values of \(t\). [1]

6 A particle travels in a straight line from a point \(P\) to a point \(Q\). Its velocity \(t\) seconds after leaving \(P\) is \(v = 4t - \frac{1}{16}t^3\). The distance \(PQ\) is 64 m.

(i) Find the time taken for the particle to travel from \(P\) to \(Q\). [5]

(ii) Find the set of values of \(t\) for which the acceleration of the particle is positive. [4]

7 Loads \(A\) and \(B\), of masses 1.2 kg and 2.0 kg respectively, are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. \(A\) is held at rest and \(B\) hangs freely, with both straight parts of the string vertical. \(A\) is released and starts to move upwards. It does not reach the pulley in the subsequent motion.

(i) Find the acceleration of \(A\) and the tension in the string. [4]

(ii) Find, for the first 1.5 metres of \(A\)’s motion,

(a) \(A\)’s gain in potential energy,

(b) the work done on \(A\) by the tension in the string,

(c) \(A\)’s gain in kinetic energy. [3]

\(B\) hits the floor 1.6 seconds after \(A\) is released. \(B\) comes to rest without rebounding and the string becomes slack.

(iii) Find the time from the instant the string becomes slack until it becomes taut again. [4]