A car of mass 800 kg is moving on a straight horizontal road with its engine working at a rate of 22.5 kW. Find the resistance to the car’s motion at an instant when the car’s speed is 18 m s\(^{-1}\) and its acceleration is 1.2 m s\(^{-2}\). [4]

Small blocks A and B are held at rest on a smooth plane inclined at 30° to the horizontal. Each is held in equilibrium by a force of magnitude 18 N. The force on A acts upwards parallel to a line of greatest slope of the plane, and the force on B acts horizontally in the vertical plane containing a line of greatest slope (see diagram). Find the weight of A and the weight of B. [4]

A block of weight 7.5 N is at rest on a plane which is inclined to the horizontal at angle \(\alpha\), where \(\tan \alpha = \frac{7}{24}\). The coefficient of friction between the block and the plane is \(\mu\). A force of magnitude 7.2 N acting parallel to a line of greatest slope is applied to the block. When the force acts up the plane (see Fig. 1) the block remains at rest.

(i) Show that \(\mu \geq \frac{17}{24}\). [4]

When the force acts down the plane (see Fig. 2) the block slides downwards.

(ii) Show that \(\mu < \frac{31}{24}\). [2]

Particles P and Q move on a straight line AOB. The particles leave O simultaneously, with P moving towards A and with Q moving towards B. The initial speed of P is 1.3 m s\(^{-1}\) and its acceleration in the direction OA is 0.1 m s\(^{-2}\). Q moves with acceleration in the direction OB of 0.016\(t\) m s\(^{-2}\), where \(t\) seconds is the time elapsed since the instant that P and Q started to move from O. When \(t = 20\), particle P passes through A and particle Q passes through B.

(i) Given that the speed of Q at B is the same as the speed of P at A, find the speed of Q at time \(t = 0\). [4]

(ii) Find the distance AB. [3]
A small block $B$ of mass 0.25 kg is attached to the mid-point of a light inextensible string. Particles $P$ and $Q$, of masses 0.2 kg and 0.3 kg respectively, are attached to the ends of the string. The string passes over two smooth pulleys fixed at opposite sides of a rough table, with $B$ resting in limiting equilibrium on the table between the pulleys and particles $P$ and $Q$ and block $B$ are in the same vertical plane (see diagram).

(i) Find the coefficient of friction between $B$ and the table.  

$Q$ is now removed so that $P$ and $B$ begin to move.

(ii) Find the acceleration of $P$ and the tension in the part $PB$ of the string.

A particle of mass 3 kg falls from rest at a point 5 m above the surface of a liquid which is in a container. There is no instantaneous change in speed of the particle as it enters the liquid. The depth of the liquid in the container is 4 m. The downward acceleration of the particle while it is moving in the liquid is 5.5 m s$^{-2}$.

(i) Find the resistance to motion of the particle while it is moving in the liquid.

(ii) Sketch the velocity-time graph for the motion of the particle, from the time it starts to move until the time it reaches the bottom of the container. Show on your sketch the velocity and the time when the particle enters the liquid, and when the particle reaches the bottom of the container.

A block of mass 60 kg is pulled up a hill in the line of greatest slope by a force of magnitude 50 N acting at an angle $\alpha$° above the hill. The block passes through points $A$ and $B$ with speeds 8.5 m s$^{-1}$ and 3.5 m s$^{-1}$ respectively (see diagram). The distance $AB$ is 250 m and $B$ is 17.5 m above the level of $A$. The resistance to motion of the block is 6 N. Find the value of $\alpha$. 

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