1 A car of mass 900 kg is moving along a straight horizontal road against a constant resistance to motion of 350 N. At an instant when the car is moving at $15\,\text{m s}^{-1}$ its acceleration is $0.25\,\text{m s}^{-2}$.

(a) Find the driving force of the car's engine at this instant. [2]

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(b) Find the power of the car's engine at this instant. [2]

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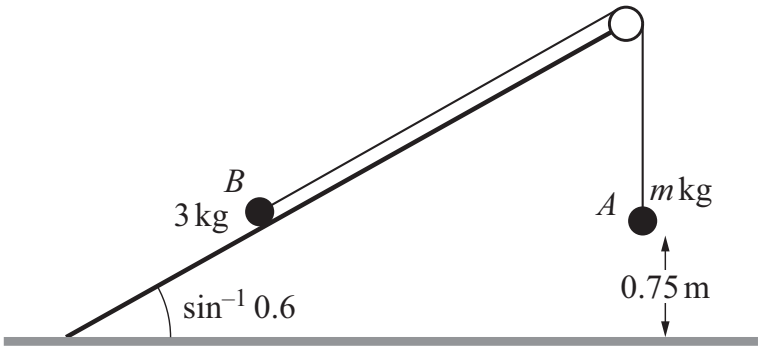

Two particles, A and B, of masses m kg and 3 kg respectively, are connected by a light inextensible string. Particle B is on a fixed plane which is at an angle of $\sin^{-1} 0.6$ to the horizontal ground. The string passes over a fixed smooth pulley at the top of the plane. Particle A hangs vertically below the pulley and is 0.75 m above the ground (see diagram).

The system is released from rest. In the subsequent motion B moves up a line of greatest slope of the plane and does not reach the pulley. As B moves up the plane there is a constant resistance to its motion of magnitude $\frac{10}{3}$ N. The speed of A immediately before it hits the ground is $2\,\text{m}\,\text{s}^{-1}$.

Use an energy method to find the value of m. [6]

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3 A car of mass 1400 kg travelling on a straight horizontal road accelerates uniformly from a speed of $15\,\text{m s}^{-1}$ to $20\,\text{m s}^{-1}$ over a distance of 175 m.

(a) Find the time taken to travel the 175 m. [2]

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There is a constant resistance force of 800 N to the motion of the car.

(b) (i) Use an energy method throughout to find the average power of the car's engine as the speed increases from $15\,\text{m s}^{-1}$ to $20\,\text{m s}^{-1}$. [4]

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(ii) Find the steady speed that the car could maintain on the horizontal road if the engine is working at the power found in **(b)(i)**. [2]

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4 A lorry of mass 18 000 kg is travelling along a straight road.

(a) On a horizontal section of the road, the power of the lorry's engine is constant. There is a constant resistance to motion of 1600 N.

(i) The steady speed which the lorry can maintain with the engine working at power P W is $30\,\text{m s}^{-1}$.

Find the value of P. [1]

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(ii) At an instant when the speed of the lorry is $16\,\text{m s}^{-1}$, its engine is working at a power of 40 kW.

Find the acceleration of the lorry at this instant. [2]

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(b) When the lorry has reached a speed of $20\,\text{m s}^{-1}$, it begins to ascend a section of road inclined at an angle $\alpha°$ to the horizontal. The engine now works at a power of 120 kW. There is no change in the lorry's speed as it ascends the hill. The constant resistance to motion remains 1600 N.

Find the value of α. [3]

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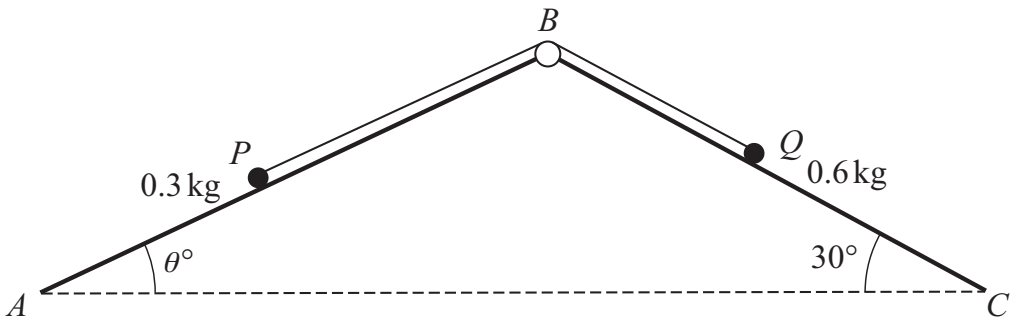

Two particles, P and Q, of masses 0.3 kg and 0.6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth pulley fixed at a point B where the inclined planes AB and BC meet. P lies on the smooth plane AB which is inclined at an angle $\theta°$ to the horizontal where $\sin\theta° = 0.4$. Q lies on the plane BC which is inclined at 30° to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes (see diagram). The particles are released from rest.

(a) It is given that the plane BC is smooth.

Find the tension in the string and the acceleration of Q. [5]

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(b) It is given instead that the plane BC is rough. The work done against the frictional force when Q moves 2 m down the plane is 1.8 J. You should assume that P does **not** reach the pulley and that Q does **not** reach C.

Use an energy method to find the speed of Q when it has moved 2 m down the plane. [4]