1 A cyclist is riding a bicycle along a straight horizontal road AB of length 50 m. The cyclist starts from rest at A and reaches a speed of $6\,\text{m}\,\text{s}^{-1}$ at B. The cyclist produces a constant driving force of magnitude 100 N. There is a resistance force, and the work done against the resistance force from A to B is 3560 J.

Find the total mass of the cyclist and bicycle. [3]

2 A particle P of mass 0.4 kg is in limiting equilibrium on a plane inclined at 30° to the horizontal.

(a) Show that the coefficient of friction between the particle and the plane is $\frac{1}{3}\sqrt{3}$. [3]

A force of magnitude 7.2 N is now applied to P directly up a line of greatest slope of the plane.

(b) Given that P starts from rest, find the time that it takes for P to move 1 m up the plane. [4]

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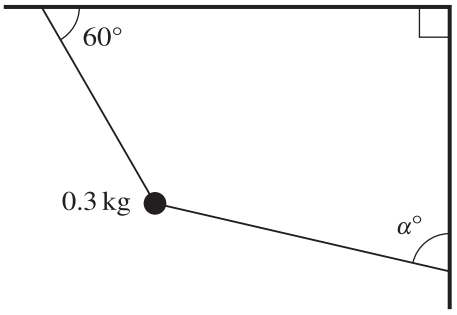

A particle of mass 0.3 kg is held at rest by two light inextensible strings. One string is attached at an angle of 60° to a horizontal ceiling. The other string is attached at an angle α° to a vertical wall (see diagram). The tension in the string attached to the ceiling is 4 N.

Find the tension in the string which is attached to the wall and find the value of α. [6]

4 A car of mass 1200 kg is travelling along a straight horizontal road AB. There is a constant resistance force of magnitude 500 N. When the car passes point A, it has a speed of $15\,\text{m s}^{-1}$ and an acceleration of $0.8\,\text{m s}^{-2}$.

(a) Find the power of the car's engine at the point A. [3]

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The car continues to work with this power as it travels from A to B. The car takes 53 seconds to travel from A to B and the speed of the car at B is $32\,\text{m s}^{-1}$.

(b) Show that the distance AB is 1362.6 m. [3]

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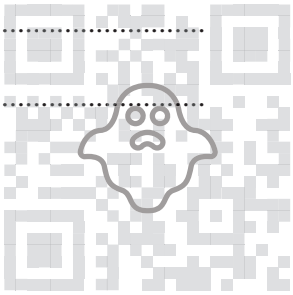

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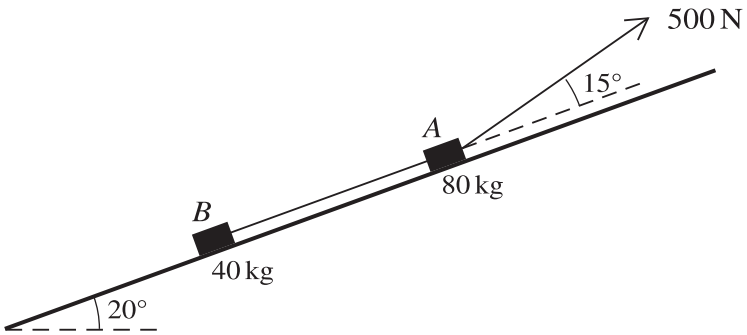

A block A of mass 80 kg is connected by a light, inextensible rope to a block B of mass 40 kg. The rope joining the two blocks is taut and is parallel to a line of greatest slope of a plane which is inclined at an angle of 20° to the horizontal. A force of magnitude 500 N inclined at an angle of 15° above the same line of greatest slope acts on A (see diagram). The blocks move up the plane and there is a resistance force of 50 N on B, but no resistance force on A.

(a) Find the acceleration of the blocks and the tension in the rope. [5]

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(b) Find the time that it takes for the blocks to reach a speed of $1.2\,\text{m}\,\text{s}^{-1}$ from rest. [2]

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6 Three particles A, B and C of masses 0.3 kg, 0.4 kg and m kg respectively lie at rest in a straight line on a smooth horizontal plane. The distance between B and C is 2.1 m. A is projected directly towards B with speed $2\,\text{m s}^{-1}$. After A collides with B the speed of A is reduced to $0.6\,\text{m s}^{-1}$, still moving in the same direction.

(a) Show that the speed of B after the collision is $1.05\,\text{m s}^{-1}$. [2]

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After the collision between A and B, B moves directly towards C. Particle B now collides with C. After this collision, the two particles coalesce and have a combined speed of $0.5\,\text{m s}^{-1}$.

(b) Find m. [2]

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(c) Find the time that it takes, from the instant when B and C collide, until A collides with the combined particle. [5]

7 A particle P travels in a straight line, starting at rest from a point O. The acceleration of P at time t s after leaving O is denoted by a m s^{-2}, where

$$a = 0.3t^{\frac{1}{2}} \quad \text{for } 0 \leqslant t \leqslant 4,$$
$$a = -kt^{-\frac{3}{2}} \quad \text{for } 4 < t \leqslant T,$$

where k and T are constants.

(a) Find the velocity of P at $t = 4$. [2]

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(b) It is given that there is no change in the velocity of P at $t = 4$ and that the velocity of P at $t = 16$ is 0.3 m s^{-1}.

Show that $k = 2.6$ and find an expression, in terms of t, for the velocity of P for $4 \leqslant t \leqslant T$. [4]

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(c) Given that P comes to instantaneous rest at $t = T$, find the exact value of T. [2]

(d) Find the total distance travelled between $t = 0$ and $t = T$. [4]