1 A particle P is projected vertically upwards with speed $u\,\text{m s}^{-1}$ from a point on the ground. P reaches its greatest height after 3 s.

(a) Find u. [1]

(b) Find the greatest height of P above the ground. [2]

2 A box of mass 5 kg is pulled at a constant speed of $1.8\,m\,s^{-1}$ for 15 s up a rough plane inclined at an angle of 20° to the horizontal. The box moves along a line of greatest slope against a frictional force of 40 N. The force pulling the box is parallel to the line of greatest slope.

(a) Find the change in gravitational potential energy of the box. [2]

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(b) Find the work done by the pulling force. [2]

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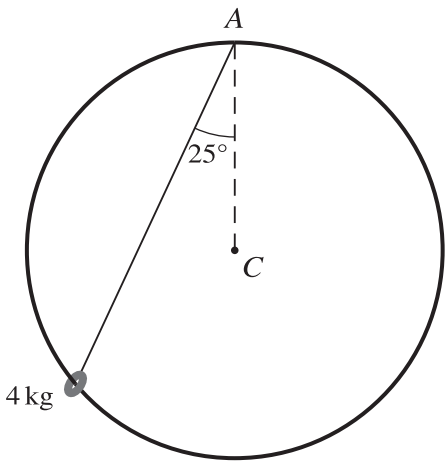

A ring of mass 4 kg is threaded on a smooth circular rigid wire with centre C. The wire is fixed in a vertical plane and the ring is kept at rest by a light string connected to A, the highest point of the circle. The string makes an angle of 25° to the vertical (see diagram).

Find the tension in the string and the magnitude of the normal reaction of the wire on the ring. [6]

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4 A particle P travels in the positive direction along a straight line with constant acceleration. P travels a distance of 52 m during the 2nd second of its motion and a distance of 64 m during the 4th second of its motion.

(a) Find the initial speed and the acceleration of P. [5]

(b) Find the distance travelled by P during the first 10 seconds of its motion. [2]

5 Particles X and Y move in a straight line through points A and B. Particle X starts from rest at A and moves towards B. At the same instant, Y starts from rest at B.

At time t seconds after the particles start moving

- the acceleration of X in the direction AB is given by $(12t + 12)\,\text{m s}^{-2}$,
- the acceleration of Y in the direction AB is given by $(24t - 8)\,\text{m s}^{-2}$.

(a) It is given that the velocities of X and Y are equal when they collide.

Calculate the distance AB. [6]

(b) It is given instead that $AB = 36$ m.

Verify that X and Y collide after 3 s. [2]

6 A car of mass 1750 kg is pulling a caravan of mass 500 kg. The car and the caravan are connected by a light rigid tow-bar. The resistances to the motion of the car and caravan are 650 N and 150 N respectively.

(a) The car and caravan are moving along a straight horizontal road at a constant speed of 24 m s^{-1}.

(i) Find the power of the car's engine. [2]

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(ii) The engine's power is now suddenly increased to 40 kW.

Find the instantaneous acceleration of the car and caravan and find the tension in the tow-bar. [5]

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(b) The car and caravan now travel up a straight hill, inclined at an angle $\sin^{-1} 0.14$ to the horizontal, at a constant speed of v m s^{-1}. The car's engine is working at 31 kW. The resistances to the motion of the car and caravan are unchanged.

Find v. [3]

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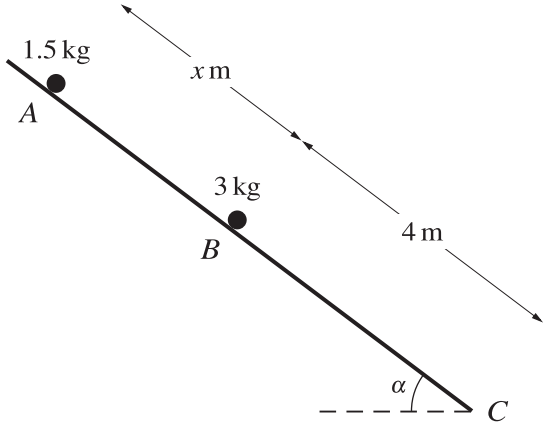

Particles of masses 1.5 kg and 3 kg lie on a plane which is inclined at an angle of α to the horizontal, where $\tan\alpha = \frac{3}{4}$. The section of the plane from A to B is smooth and the section of the plane from B to C is rough. The 1.5 kg particle is held at rest at A and the 3 kg particle is in limiting equilibrium at B. The distance AB is x m and the distance BC is 4 m (see diagram).

(a) Show that the coefficient of friction between the particle at B and the plane is 0.75. [3]

The 1.5 kg particle is released from rest. In the subsequent motion the two particles collide and coalesce. The time taken for the combined particle to travel from B to C is 2 s. The coefficient of friction between the combined particle and the plane is still 0.75.

(b) Find x. [6]

(c) Find the total loss of energy of the particles from the time the 1.5 kg particle is released until the combined particle reaches C. [3]