1 A car of mass 750 kg moves along a level straight road at a constant velocity of $20\,m\,s^{-1}$. The engine produces a driving force of 3000 N.

a Write the magnitude of the resisting force. **[1 mark]**

The car increases the driving force to 6000 N. Assuming that the resisting force remains constant,

b Find the acceleration of the car, **[2]**

c Calculate the distance travelled by the car as it increases its speed from $20\,m\,s^{-1}$ to $30\,m\,s^{-1}$. **[2]**

2 Two particles, P and Q, of mass 20 kg and 30 kg respectively, are connected by a light inextensible string, passing over a fixed smooth light pulley. The particles are released from rest with the string taut, and the hanging parts vertical. Find

a The acceleration of P, **[6]** **b** The tension in the string. **[1]**

3 A small block of mass 5 kg is released from rest at the surface of a lake of still water. The water offers a constant resisting force of 29 N.

a Calculate the acceleration of the block. **[3]**

After 8 seconds the block hits the bottom of the lake.

b How fast is the block moving when it hits the bottom of the lake? **[2]**

c How deep is the lake at that point? **[2]**

4 A car of mass 1200 kg tows a caravan of mass 800 kg along a horizontal road. The car and the caravan experience resistances of 500 N and 300 N respectively. The constant horizontal force driving the car forwards is 1500 N.

Set up equations of motion for the car and the caravan and solve to find

a The acceleration of the car and the caravan, **[6]**

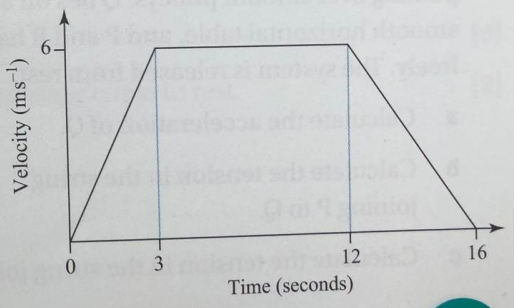
b The tension in the tow bar connecting the car and the caravan. **[1]**

5 The upwards motion of a lift between two floors is in three stages. Firstly the lift accelerates from rest at $2\,m\,s^{-2}$ until it reaches a velocity of $6\,m\,s^{-1}$. It maintains this velocity for 5 seconds, after which it slows to rest with a deceleration of $3\,m\,s^{-2}$.

a Draw a velocity-time graph for the motion of the lift between the two floors. **[3]**

b Calculate the reaction force between a man of mass 100 kg and the floor of the lift during each of the three stages of the motion. **[5]**

6 The diagram shows the velocity-time graph for the motion of a lift moving up between two floors in a tall building. A parcel of mass 40 kg rests on the floor of the lift. Calculate the vertical force exerted by the floor of the lift on the parcel between



a t = 0 and t = 3 **[3]**

b t = 3 and t = 12 **[2]**

c t = 12 and t = 15 **[3]**

7 A lorry of mass 1900 kg tows a trailer of mass 800 kg along a straight horizontal road. The lorry and the trailer are connected by a light horizontal tow bar. The lorry and the trailer experience resistances to motion of 700 N and 400 N respectively. The constant horizontal driving force on the lorry is 2900 N.

a Set up equations of motion for the lorry and the trailer. [4]

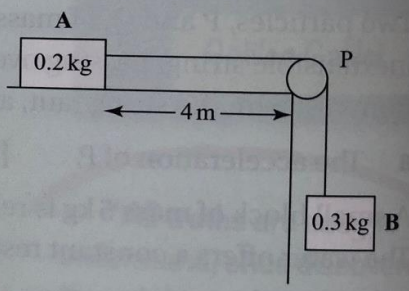
b Use your equations to work out

i The acceleration of the lorry and the trailer, **ii** The tension in the tow bar. [3]

When the speed of the vehicles is $12\,\text{m s}^{-1}$ the tow bar breaks. The resistance to the motion of the trailer remains 400 N.

c Find the distance moved by the trailer from the moment the tow bar breaks to the moment the trailer comes to rest. [4]

8 Two boxes, A and B, of masses 0.2 kg and 0.3 kg respectively are connected by a light, inextensible string that passes over a smooth pulley, P. Initially A is at rest on a rough horizontal platform, a distance 4 m from the pulley, and B hangs freely. The system is released from rest. A experiences a constant resisting force of $0.15g$. In this question give your answers in terms of g



a Calculate the acceleration of A. [5]

When A is 1 metre from the pulley, the string breaks.

b Calculate the velocity of A at this instant. [2]

c Calculate the deceleration of A after the string has broken. [2]

d Show that A is moving at a speed of $\sqrt{\frac{3g}{10}}\ \text{m s}^{-1}$ when it hits the pulley. [2]

9 Two particles, A and B, of masses 2 kg and 3 kg respectively are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The system is released from rest with both masses a height of 72 cm above a horizontal table. Calculate

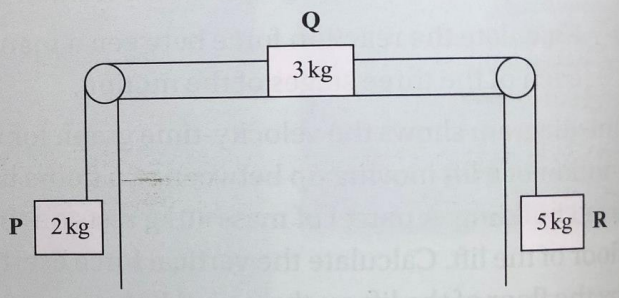
a The speed with which B hits the table, [8]

b How long it takes for B to hit the table. [2]

When B has hit the table, particle A continues upwards without hitting the pulley.

c Calculate the greatest height above the table reached by A. [3]

10 The diagram shows three bodies, P, Q and R, connected by two light inextensible strings, passing over smooth pulleys. Q lies on a smooth horizontal table, and P and R hang freely. The system is released from rest.



a Calculate the acceleration of Q. [8]

b Calculate the tension in the string joining P to Q. [2]

c Calculate the tension in the string joining Q to R. [2]

11 A lift of mass 820 kg transports a woman of mass 80 kg. The lift is accelerating upwards at $4\,m\,s^{-2}$.

a Calculate the tension in the lift cable. [2]

b Calculate the vertical force exerted on the woman by the floor of the lift. [2]

Some time later the tension in the lift cable is 8640 N.

c Calculate the acceleration of the lift. [2]

d Calculate the vertical force exerted on the woman by the floor of the lift. [2]

12 A tug of mass 8000 kg is pulling a barge of mass 6000 kg along a canal. The tug and the barge are connected by an inextensible horizontal tow rope. The tug and the barge experience resistances to motion of 1200 N and 600 N respectively. The tug is accelerating at $0.2\,m\,s^{-2}$. Find

a The force in the tow rope, [2]

b The tractive force of the tug. [2]

The tow rope can operate safely up to a maximum force of 2100 N.

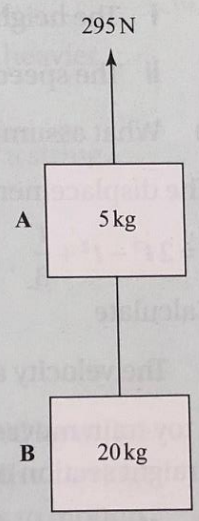
c Calculate the maximum safe tractive force for the tug. [4]

13 A car of mass 1000 kg tows a trailer of mass 400 kg along a horizontal road. The engine of the car exerts a forward force of 4.9 kN. The car and the trailer experience resisting forces that are each proportional to their masses. Given that the car accelerates at $3\,m\,s^{-2}$ find

a The tension in the tow bar, [7]

b The resisting force on the trailer. [1]

14 A body, B, of mass 20 kg, hangs below a mass, A, of 5 kg, connected by a light inextensible string. The system is lifted by a vertical force of 295 N, applied to A



a Calculate the acceleration of A. **[6]**

b Calculate the tension in the string between A and B. **[2]**

15 A locomotive of mass 10 tonnes pushes a carriage of mass 5 tonnes along straight, horizontal rails. The locomotive and the carriage are joined by a horizontal coupling. The locomotive and the carriage experience resisting forces of 3 kN and 2 kN respectively. They accelerate at $0.3\,m\,s^{-2}$. Find

a The force in the coupling, **[2]**

b The force of the engine on the locomotive. **[3]**

When the locomotive and the carriage are travelling at $20\,m\,s^{-1}$, the locomotive turns off its engine.

c Calculate the new force in the coupling. **[8]**

d Calculate the time until the locomotive and the carriage come to rest. **[2]**