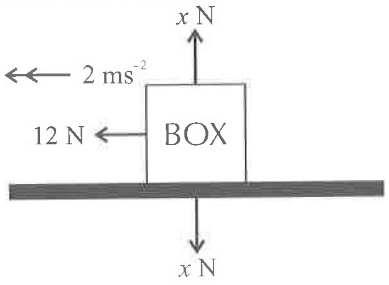
Forces and Newton's Laws

This section contains more pulleys and ropes than a medieval siege weaponry convention. Jokes aside, the maths can get pretty messy when you're working on these questions, so take your time and don't skip steps.

1 A box of weight x N is being pulled along a horizontal table by a force of 12 N. The box is moving in the direction of the pulling force and is accelerating at 2 ms^{-2}. Shinji draws the following diagram to help him model the forces acting on the box:



a) Look at Shinji's diagram. Identify **two** modelling assumptions that Shinji has made.

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(2 mark)

b) Calculate x.

$x =$ .....

(3 marks)

2 A rocket with mass 1 400 000 kg is launched vertically upwards by engines providing a force of 34 000 000 N.

a) Scientists model the rocket's flight assuming no other forces act on the rocket. Find the rocket's expected acceleration using this model.

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(2 marks)

b) Observers on the ground notice that the rocket's actual acceleration is 12 ms^{-2}. Find the magnitude of the total resistive force, R, acting on the rocket.

$R =$ .....

(2 marks)

c) Besides assuming that acceleration is constant, state one other assumption made in part b).

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(1 mark)

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3 A car, of mass 1600 kg, is towing a horse box of mass 3000 kg along a straight, horizontal road. The car experiences a resistive force of magnitude 400 N and the horse box experiences a constant resistive force of magnitude R N. A driving force of magnitude 4300 N acts on the car. The vehicles accelerate at 0.8 ms^{-2}.

a) Assuming that the tow bar connecting the car to the horse box is horizontal, find the tension, T, in the tow bar.

$T =$ .....

(3 marks)

b) Find the resistance force, R, acting on the horse box.

$R =$ .....

(3 marks)

When the car and horse box are travelling at a speed of 7 ms^{-1}, the horse box becomes detached from the car. Assume that the only horizontal force now acting on the horse box is the resistive force R.

c) Find the deceleration of the horse box.

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(2 marks)

d) Find the distance the horse box travels before it comes to rest.

You'll need to use a suvat equation to answer this question.

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(3 marks)

4 A particle of mass 0.5 kg moves under the action of two forces, $\mathbf{F}_1$ and $\mathbf{F}_2$, where $\mathbf{F}_1 = (3\mathbf{i} + 2\mathbf{j})$ N and $\mathbf{F}_2 = (2\mathbf{i} - \mathbf{j})$ N. Find the acceleration of the particle, giving your answer in **i** and **j** vector form.

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(3 marks)

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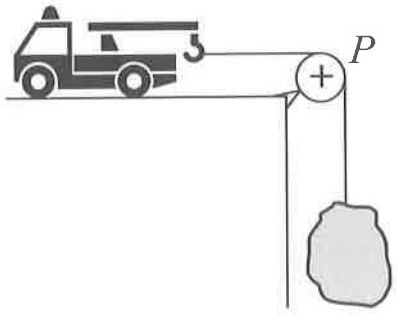
5 A truck of mass 3000 kg and a rock of mass 500 kg are connected by a rope. The rope passes over a pulley P as shown in the diagram.



The system begins at rest and the rope is taut. The truck begins to move away from P. Its engine produces a constant driving force of 10 000 N. A constant resistance force between the truck and the ground is modelled as having a magnitude of 800 N.

The rope is modelled as light and inelastic. The pulley is modelled as light and smooth.

a) Using this model, find the acceleration of the rock towards the pulley P. Give your answer to three significant figures.

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(5 marks)

It was found that the rock was actually accelerating at 0.8 ms^{-2}.

b) Using this information, suggest one improvement that could be made to the model. Give a reason for your answer.

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(2 marks)

6 A woman is travelling in a lift. The lift is rising vertically and is accelerating at a rate 0.75 ms^{-2}. The lift is pulled upwards by a light, inextensible cable. The tension in the cable is T N and the lift has mass 500 kg. The floor of the lift exerts a force of 675 N on the woman. Find T.

$T =$ .....

(4 marks)

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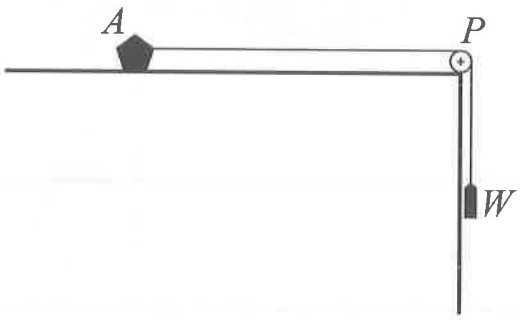
7 A particle, A, is attached to a weight, W, by a light inextensible string which passes over a smooth pulley, P, as shown. When the system is released from rest, with the string taut, A and W experience an acceleration of 4 ms^{-2}. A moves across a rough horizontal plane and W falls vertically. The mass of W is 1.5 times the mass of A.



a) Given that the mass of A is 0.2 kg, find the resistance force acting on A in the horizontal plane.

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(4 marks)

W falls for h m until it hits the ground and does not rebound. A continues to move until it reaches P with speed 3 ms^{-1}. The initial distance between A and P is $\frac{7}{4}h$ m.

b) Find the time taken for W to hit the ground.

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(7 marks)

c) How did you use the information that the string is inextensible?

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(1 mark)

EXAM TIP

There's usually a few easy marks to be picked up on difficult mechanics questions by being able to talk about the modelling assumptions that have been made. Also, you could be asked to talk about how the model could be improved. So, make sure you know what all those fiddly mechanics terms like 'particle', 'inextensible', 'light', 'rough' and 'smooth' mean. Exciting stuff...

Score