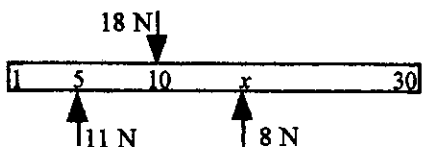
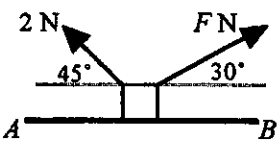


Take $g = 9.8 \text{ ms}^{-2}$ and give all answers correct to 3 significant figures where necessary.

1. A boy holds a 30 cm metal ruler between three fingers of one hand, pushing down with the middle finger and up with the other two, at the points marked 5 cm, 10 cm and x cm and exerting forces of magnitude 11 N, 18 N and 8 N respectively. The ruler is in equilibrium in this position. Modelling the ruler as a uniform rod, find
- 
- (a) the mass of the ruler, in grams, (3 marks)
- (b) the value of x . (3 marks)
- (c) State how you have used the modelling assumption that the ruler is a uniform rod. (1 mark)

2.  A small packet of mass 0.3 kg rests on a rough horizontal surface. The coefficient of friction between the packet and the surface is $\frac{1}{4}$. Two strings are attached to the packet, making angles of 45° and 30° with the horizontal, and when forces of magnitude 2 N and F N are exerted through the strings as shown, the packet is on the point of moving in the direction \overrightarrow{AB} . Find the value of F . (7 marks)

3. A body moves in a straight line with constant acceleration. Its speed increases from 17 ms^{-1} to 33 ms^{-1} while it travels a distance of 250 m. Find
- (a) the time taken to travel the 250 m, (3 marks)
- (b) the acceleration of the body. (2 marks)
- The body now decelerates at a constant rate from 33 ms^{-1} to rest in 6 seconds.
- (c) Find the distance travelled in these 6 seconds. (2 marks)

4. A particle P of mass m kg, at rest on a smooth horizontal table, is connected to particles Q and R , of mass 0.1 kg and 0.5 kg respectively, by strings which pass over fixed pulleys at the edges of the table. The system is released from rest with Q and R hanging freely and it is found that the tension in the section of the string between P and R is 2 N.
- (a) Show that the acceleration of the particles has magnitude 5.8 ms^{-2} . (3 marks)
- (b) Find the value of m . (5 marks)

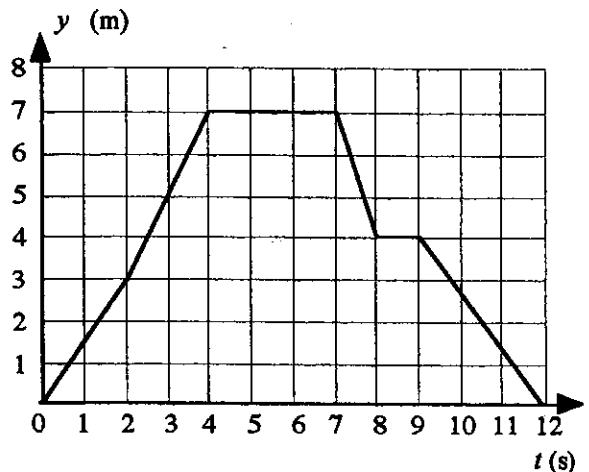
Modelling assumptions have been made about the pulley and the strings.

- (c) Briefly describe these two assumptions. For each one, state how the mathematical model would be altered if the assumption were not made. (4 marks)

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5. Two trucks P and Q , of masses 18 000 kg and 16 000 kg respectively, collide while moving towards each other in a straight line. Immediately before the collision, both trucks are travelling at the same speed, $u \text{ ms}^{-1}$. Immediately after the collision, P is moving at half its original speed, its direction of motion having been reversed.
- (a) Find, in terms of u , the speed of Q immediately after the collision. **(5 marks)**
 - (b) State, with a reason, whether the direction of Q 's motion has been reversed. **(1 mark)**
 - (c) Find, in terms of u , the magnitude of the impulse exerted by P on Q in the collision, stating the units of your answer. **(3 marks)**
- The force exerted by each truck on the other in the impact has magnitude $108\,000u \text{ N}$.
- (d) Find the time for which the trucks are in contact. **(3 marks)**

6. A particle P moves in a straight line such that its displacement from a fixed point O at time t s is y metres. The graph of y against t is as shown.



- (a) Write down the velocity of P when
 - (i) $t = 1$, (ii) $t = 10$. **(2 marks)**
 - (b) State the total distance travelled by P . **(2 marks)**
 - (c) Write down a formula for y in terms of t when $2 \leq t < 4$. **(3 marks)**
 - (d) Sketch a velocity-time graph for the motion of P during the twelve seconds. **(3 marks)**
 - (e) Find the maximum speed of P during the motion. **(3 marks)**
7. Two trains S and T are moving with constant speeds on straight tracks which intersect at the point O . At 9.00 a.m. S has position vector $(-10\mathbf{i} + 24\mathbf{j}) \text{ km}$ and T has position vector 25 km relative to O , where \mathbf{i} and \mathbf{j} are unit vectors in the directions due east and due north respectively. S is moving with speed 52 km h^{-1} and T is moving with speed 50 km h^{-1} , both towards O .
- (a) Show that the velocity vector of S is $(20\mathbf{i} - 48\mathbf{j}) \text{ km h}^{-1}$ and find the velocity vector of T . **(5 marks)**
 - (b) Find expressions for the position vectors of S and T at time t minutes after 9.00 a.m. **(5 marks)**
 - (c) Show that the bearing of T from S remains constant during the motion, and find this bearing. **(5 marks)**
 - (d) Show that if the trains continue at the given speeds they will collide. **(2 marks)**