



Forces



REVISE THIS
TOPIC

1 A particle P has mass 4 kg.

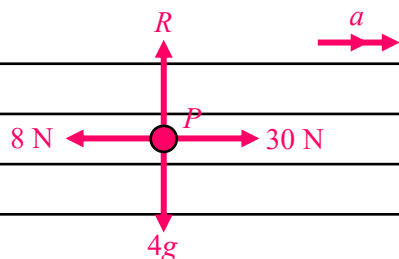
The particle is pulled along a rough horizontal surface by a horizontal force of magnitude 30 N against a constant friction force of magnitude 8 N.

(a) Find

- (i) the weight of P . (1)
- (ii) the magnitude of the normal reaction force between P and the surface. (1)
- (iii) the acceleration of P . (2)

(b) Given that P starts from rest, find

- (i) the distance travelled by P in the first 4 seconds. (2)
- (ii) the speed of P after 4 seconds. (1)



(a) (i) $W = mg$

$W = 4 \times 9.8$

$W = 39.2 \text{ N}$

(ii) 39.2 N

(b) (i) $s = s$

$u = 0$

$v = v$

$a = 5.5$

$t = 4$

$s = ut + \frac{1}{2}at^2$

$s = (0)(4) + \frac{1}{2}(5.5)(4)^2$

$s = 44 \text{ m}$

(ii) $v = u + at$

$v = 0 + 5.5(4)$

$v = 22 \text{ ms}^{-1}$

$30 - 8 = 4a$

$22 = 4a$

$a = 5.5 \text{ ms}^{-2}$

(Total for Question 1 is 7 marks)





- 2 The mass of particle P is h kg and the mass of particle Q is $5h$ kg, where h is a constant.

Particle P moves on a smooth horizontal surface under the action of a single horizontal force of magnitude 12 N.

Particle Q moves on a rough horizontal surface under the action of a horizontal force of magnitude 25 N and a frictional force of magnitude 4 N.

- (a) Given that the acceleration of Q is 1.4 ms^{-2} , find

(i) the value of h .

(2)

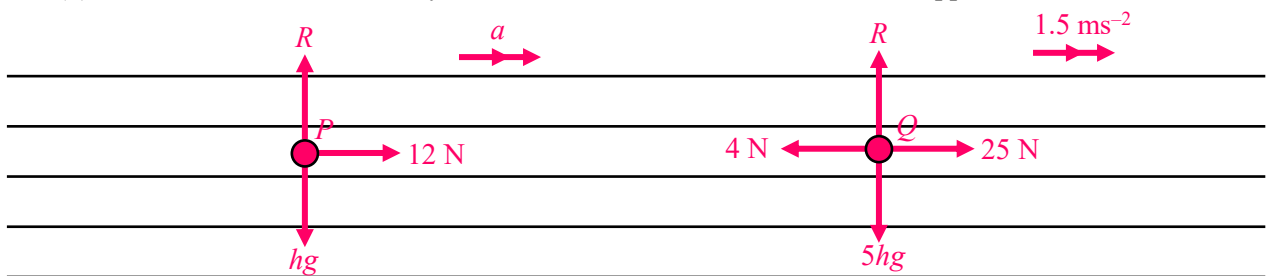
(ii) the acceleration of P .

(2)

At the instant when the force of magnitude 12 N is first applied to P , P is moving with speed 5 ms^{-1} , in the direction of the force.

- (b) Find the distance travelled by P in the first 3 seconds after the force is applied.

(2)



(a) (i) $F = ma$

$$25 - 4 = (5h) \times 1.4$$

$$21 = 7h$$

$$h = 3$$

(ii) $F = ma$

$$12 = h \times a$$

$$12 = 3a$$

$$a = 4 \text{ ms}^{-2}$$

(b) $s = s$ $s = ut + \frac{1}{2}at^2$

$$u = 5 \quad s = (5)(3) + \frac{1}{2}(4)(3)^2$$

$$v = v \quad s = 33 \text{ m}$$

$$a = 4$$

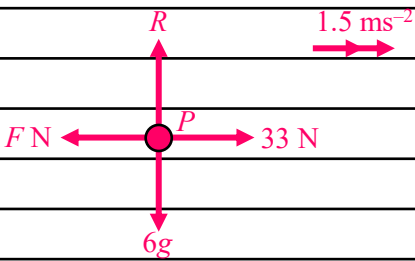
$$t = 3$$

(Total for Question 2 is 6 marks)



- 3 A particle P , of mass 6 kg is moving along a rough horizontal surface.
- A horizontal force of magnitude 33 N acts on P in the direction of motion.
- (a) Given that P accelerates at 4 ms^{-2} , find the magnitude of the frictional force acting on P . (2)
- When P reaches a speed of 12 ms^{-1} , the horizontal force of magnitude 33 N is removed.
- (b) Assuming that the frictional force remains constant, find the time taken for P to come to rest. (3)

(a)



$F = ma$
 $33 - F = 6 \times 4$
 $33 - F = 24$
 $33 - 24 = F$
 $F = 9\text{ N}$

(b)
 $F = ma$
 $-9 = 6a$
 $a = -1.5\text{ ms}^{-2}$

$s = s$
 $v = u + at$
 $u = 12$
 $0 = 12 - 1.5t$
 $v = 0$
 $1.5t = 12$
 $a = -1.5$
 $t = 8\text{ seconds}$
 $t = t$



4 A particle P is moving horizontally at a constant speed of 8 ms^{-1} .

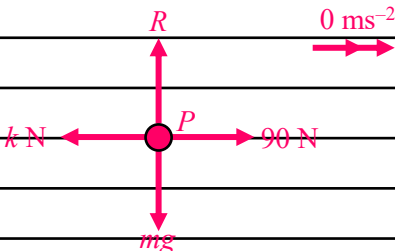
A horizontal force of magnitude 90 N acts on P in the direction of motion.
A constant resistance force of magnitude $k \text{ N}$ also acts on P .

(a) Find the value of k . (1)

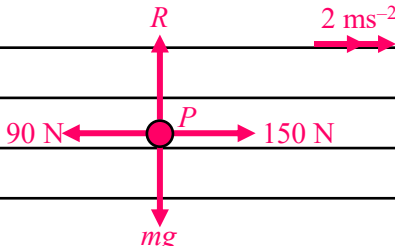
The horizontal force is then increased to 150 N while the resistance force remains constant.
 P accelerates uniformly and reaches a speed of 14 ms^{-1} after 3 seconds.

(b) Find the acceleration of P . (2)

(c) Find the mass of P . (2)

(a) 	$F = ma$ $90 - k = m \times 0$ $90 - k = 0$ $k = 90$
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(b) $s = s$ $u = 8$ $v = 14$ $a = a$ $t = 3$	$v = u + at$ $14 = 8 + 3a$ $6 = 3a$ $a = 2 \text{ ms}^{-2}$
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(c) 	$F = ma$ $150 - 90 = m \times 2$ $60 = 2m$ $m = 30 \text{ kg}$
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(Total for Question 4 is 5 marks)



5 A lift of mass 800 kg is attached to a vertical cable.

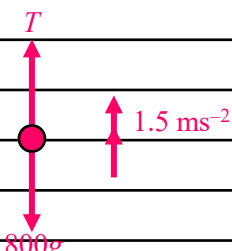
The lift starts from rest and accelerates vertically upwards at 1.5 ms^{-2} for 4 seconds.

(a) Find the tension in the cable during these 4 seconds. (2)

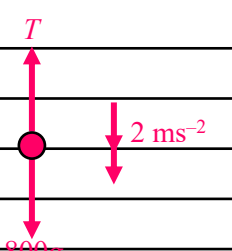
(b) Find the speed of the lift after 4 seconds. (1)

The lift then continues to move vertically upwards but decelerates uniformly, coming to rest 3 seconds later.

(c) Find the tension in the cable during the 3 seconds when the lift decelerates. (3)

(a)		$F = ma$ $T - 800g = 800 \times 1.5$ $T - 7840 = 1200$ $T = 9040 \text{ N}$
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(b)	$s = s$ $u = 0$ $v = v$ $a = 1.5$ $t = 4$	$v = u + at$ $v = 0 + (1.5)(4)$ $v = 6 \text{ ms}^{-1}$
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(c)	$s = s$ $u = 6$ $v = 0$ $a = a$ $t = 3$	$v = u + at$ $0 = 6 + 3a$ $3a = -6$ $a = -2 \text{ ms}^{-2}$		$F = ma$ $800g - T = 800 \times 2$ $7840 - T = 1600$ $7840 - 1600 = T$ $T = 6240 \text{ N}$
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6 A car of mass 1200 kg is travelling at 10 ms^{-1} along a straight horizontal road.

The car accelerates uniformly and reaches a speed of 22 ms^{-1} after travelling 96 m.

A constant resistance of 500 N acts on the car.

(a) Find the acceleration of the car. (2)

(b) Find the driving force acting on the car. (2)

The driver applies the brakes. The driving force is removed and the brakes exert an additional force of 2500 N opposing the motion of the car. The resistance force remains constant at 500 N.

(c) Find the magnitude of the deceleration of the car. (2)

(d) Find the distance travelled by the car before it comes to rest. (2)

(a)	$s = 96$	$v^2 = u^2 + 2as$
	$u = 10$	$(22)^2 = (10)^2 + 2a(96)$
	$v = 22$	$484 = 100 + 192a$
	$a = a$	$384 = 192a$
	$t = t$	$a = 2 \text{ ms}^{-2}$

(b)		$F - 500 = 1200 \times 2$
		$F - 500 = 2400$
		$F = 2900 \text{ N}$

(c)		$2500 + 500 = 1200 \times a$
		$3000 = 1200a$
		$a = 2.5 \text{ ms}^{-2}$

(d)	$s = s$	$v^2 = u^2 + 2as$
	$u = 22$	$(0)^2 = (22)^2 + 2(-2.5)s$
	$v = 0$	$0 = 484 - 5s$
	$a = -2.5$	$5s = 484$
	$t = t$	$s = 96.8 \text{ m}$

(Total for Question 6 is 8 marks)

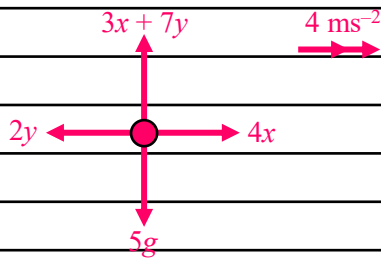


7 A particle P , of mass 5 kg is moving along a rough horizontal surface.

A horizontal force of magnitude $4x \text{ N}$ acts on P in the direction of motion. The frictional force acting on P has magnitude $2y \text{ N}$, where x and y are constants.

The magnitude of the normal reaction on P is $(3x + 7y) \text{ N}$.

Given that P accelerates at 4 ms^{-2} , find the values of x and y .



Normal Reaction = weight

$F = ma$

$$3x + 7y = 5 \times 9.8$$

$$4x - 2y = 5 \times 4$$

$$3x + 7y = 49$$

$$4x - 2y = 20$$

$$3x + 7y = 49$$

Solving simultaneous equations using calculator gives

$$4x - 2y = 20$$

$$x = 7 \quad y = 4$$





8 A ball is falling vertically.

When $t = 3$,

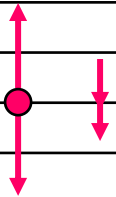
- the weight of the ball is $2c^2$ N, where c is a constant
- the air resistance has magnitude $(17c - 30)$ N
- the acceleration of the ball is 0 ms^{-2}
- the speed of the ball is 30 ms^{-1}
- the ball is 18 m above the ground.

(a) Find two possible values of c . (3)

(b) Given that the mass of the ball is less than 2 kg, find the mass of the ball. (2)

After $t = 3$, the acceleration of the ball remains 0 ms^{-2}

(c) find the value of t when the ball hits the ground. (2)

(a)	$(17c - 30)$  $2c^2$	$F = ma$ $2c^2 - (17c - 30) = m \times 0$ $2c^2 - 17c + 30 = 0$ $(2c - 5)(c - 6) = 0$ $c = 2.5 \quad c = 6$
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(b)	$W = mg$ $2c^2 = m \times 9.8$ $m = \frac{2c^2}{9.8}$	If $c = 2.5$ $m = \frac{2(2.5)^2}{9.8} = 1.275510204 \text{ kg}$	If $c = 6$ $m = \frac{2(6)^2}{9.8} = 7.346938776 \text{ kg}$
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$$m < 2 \text{ so } m = 1.3 \text{ kg}$$

(c)	$s = 18$ $u = 30$ $v = v$ $a = 0$ $t = t$	$s = ut + \frac{1}{2}at^2$ $18 = 30t + \frac{1}{2}(0)t^2$ $18 = 30t$ $t = 0.6 \text{ seconds to hit the ground from when } t = 3$ $t = 3 + 0.6$ $t = 3.6 \text{ seconds}$
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(Total for Question 8 is 7 marks)

