1 Each of the following diagrams shows a body of mass 5 kg lying initially at rest on rough horizontal ground. The coefficient of friction between the body and the ground is $\frac{1}{7}$. In each diagram R is the normal reaction of the ground on the body and F is the frictional force exerted on the body. Any other forces applied to the body are as shown on the diagrams.

Hint The forces acting on the body can affect the magnitude of the normal reaction. In part **d** the normal reaction is $(5g + 14)$ N, so $F_{MAX} = \mu(5g + 14)$ N.

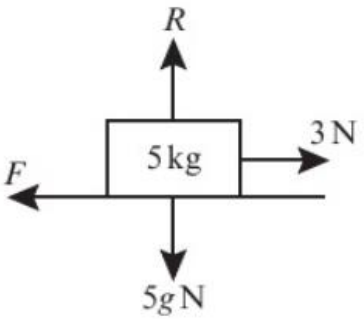
In each case

i find the magnitude of F,

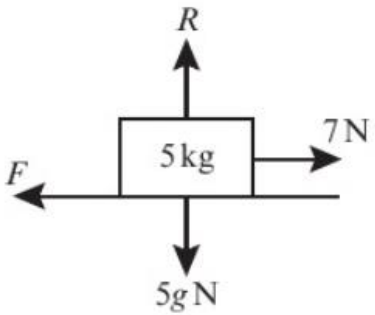
ii state whether the body will remain at rest or accelerate from rest along the ground,

iii find, when appropriate, the magnitude of this acceleration.

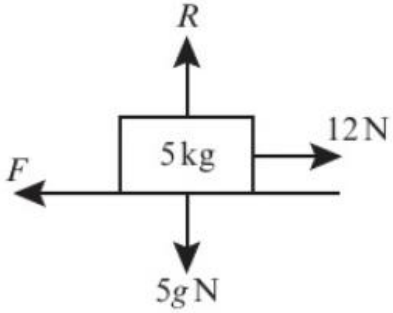
a



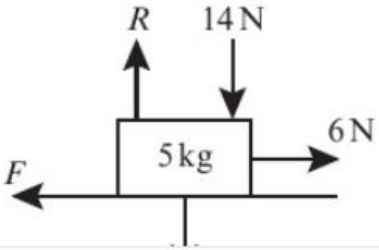
b



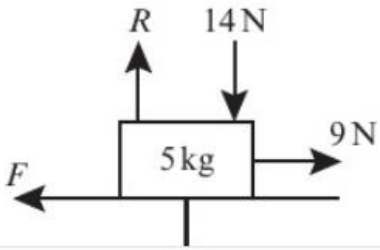
c



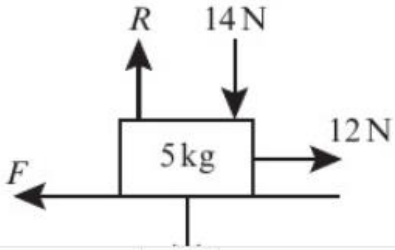
d



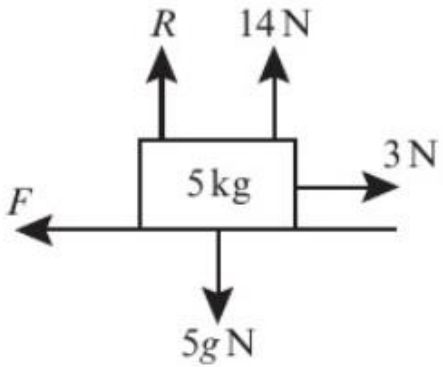
e



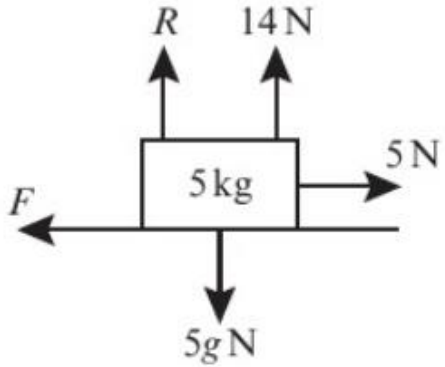
f



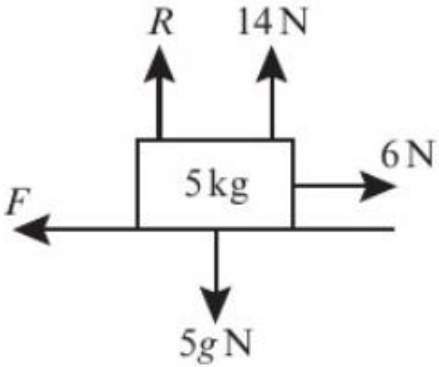
g


R
14 N
3 N
F
5 kg
5g N

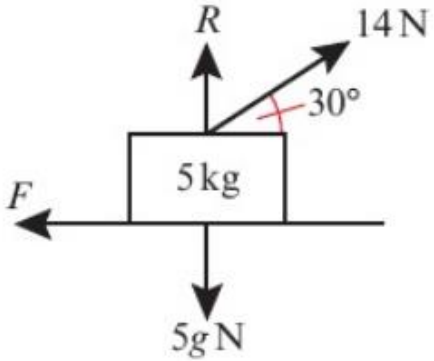
h


R
14 N
5 N
F
5 kg
5g N

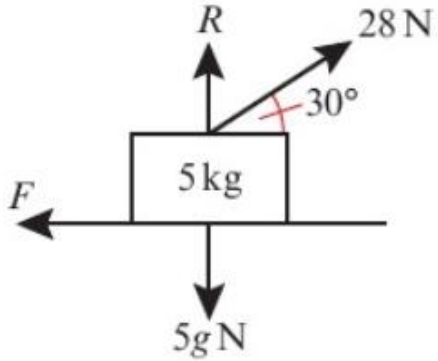
i


R
14 N
6 N
F
5 kg
5g N

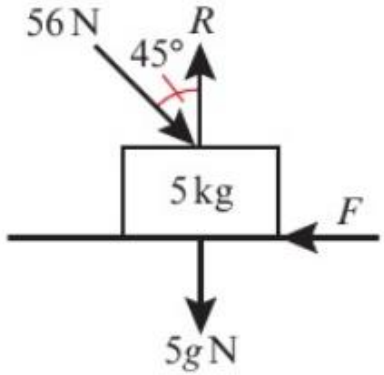
j


R
14 N
30°
F
5 kg
5g N

k

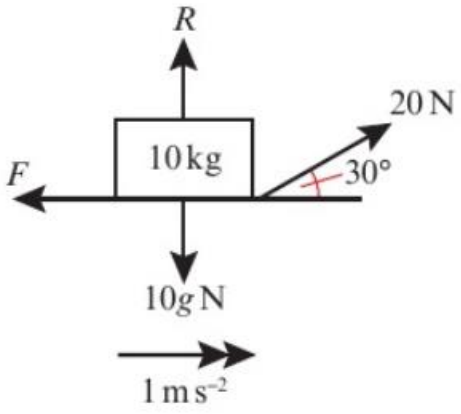

R
28 N
30°
F
5 kg
5g N

l

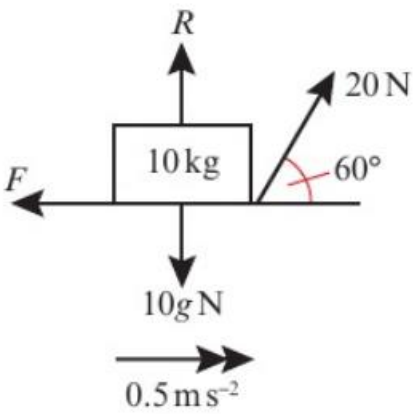

56 N
R
45°
5 kg
F
5g N

2 In each of the following diagrams, the forces shown cause the body of mass 10 kg to accelerate as shown along the rough horizontal plane. R is the normal reaction and F is the frictional force. Find the normal reaction and the coefficient of friction in each case.

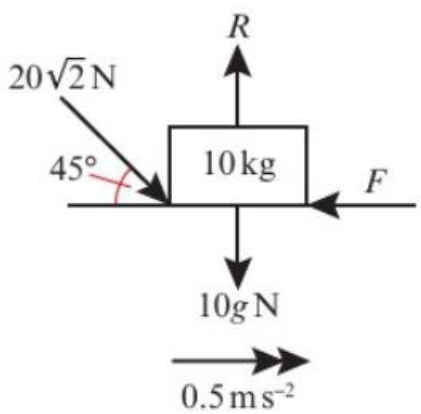
a



b



c



(E) **3** A particle of mass 0.5 kg is sliding down a rough slope that is angled at 15° to the horizontal. The acceleration of the particle is 0.25 m s^{-2}. Calculate the coefficient of friction between the particle and the slope. **(3 marks)**

(E) **4** A particle of mass 2 kg is sliding down a rough slope that is angled at 20° to the horizontal. A force of magnitude P acts parallel to the slope and is attempting to pull the particle up the slope. The acceleration of the particle is 0.2 m s^{-2} down the slope and the coefficient of friction between the particle and the slope is 0.3. Find the value of P. **(4 marks)**

5 A particle of mass 5 kg is being pushed up a rough slope that is angled at 30° to the horizontal by a horizontal force P. Given that the coefficient of friction is 0.2 and the acceleration of the particle is 2 m s^{-2} calculate the value of P.

E/P **6** A sled of mass 10 kg is being pulled along a rough horizontal plane by a force P that acts at an angle of 45° to the horizontal. The coefficient of friction between the sled and the plane is 0.1.

Given that the sled accelerates at 0.3 m s^{-2}, find the value of P.

(7 marks)

P **7** A train of mass m kg is travelling at 20 m s^{-1} when it applies its brakes, causing the wheels to lock up. The train decelerates at a constant rate, coming to a complete stop in 30 seconds.

Problem-solving

Use the formulae for constant acceleration.

← Year 1, Chapter 9

a By modelling the train as a particle, show that, in this model, the coefficient of friction between the railway track and the wheels of the train is $\mu = \frac{2}{3g}$.

The train is no longer modelled as a particle, so that the effects of air resistance can be taken into account.

b State, with a reason, whether the coefficient of friction between the track and the wheels will increase or decrease in this revised model.

1 **a** **i** 3 N **ii** $F = 3$ N and body remains at rest

b **i** 7 N **ii** $F = 7$ N and body remains at rest in limiting equilibrium

c **i** 7 N **ii** $F = 7$ N and body accelerates **iii** $1\,\text{m s}^{-2}$

d **i** 6 N **ii** $F = 6$ N and body remains at rest

e **i** 9 N **ii** $F = 9$ N and body remains at rest in limiting equilibrium

f **i** 9 N **ii** $F = 9$ N and body accelerates **iii** $0.6\,\text{m s}^{-2}$

g **i** 3 N **ii** $F = 3$ N and body remains at rest

h **i** 5 N **ii** $F = 5$ N and body remains at rest in limiting equilibrium

i **i** 5 N **ii** $F = 5$ N and body accelerates **iii** $0.2\,\text{m s}^{-2}$

j **i** 6 N **ii** $F = 6$ N and body accelerates **iii** $1.22\,\text{m s}^{-2}$ (3 s.f.)

k **i** 5 N **ii** $F = 5$ N and body accelerates **iii** $3.85\,\text{m s}^{-2}$ (3 s.f.)

l **i** 12.7 N (3 s.f.) **ii** The body accelerates. **iii** $5.39\,\text{m s}^{-2}$ (3 s.f.)

2 **a** $R = 88$ N, $\mu = 0.083$ (2 s.f.)

b $R = 80.679$ N, $\mu = 0.062$ (2 s.f.)

c $R = 118$ N, $\mu = 0.13$ (2 s.f.)

3 0.242 (3 s.f.)

4 0.778 N (3 s.f.)

5 56.1 N (3 s.f.)

6 16.5 N (3 s.f.)

7 **a** Use $v = u + at$ to find $a = -\frac{2}{3}\text{ms}^{-2}$

R($\rightarrow$): $-\mu mg = -\frac{2}{3}m$

$\mu = \frac{2}{3g}$

b Let A be a constant resistive force of air resistance.

From part **a**, $a = -\frac{2}{3}$

R($\rightarrow$) and using Newton's second law: $-\mu mg - A = -\frac{2}{3}m$

So $\mu mg = \frac{2}{3g} - \frac{A}{mg} < \frac{2}{3g}$