Past-paper walk-through

Newton's laws of motion ▪ 4.4

eXercise

Questions in this set

- 9709/41 N25 Q1 ▪ 4 marks
- 9709/41 N25 Q5 ▪ 6 marks
- 9709/41 N25 Q8 ▪ 8 marks
- 9709/42 N25 Q2 ▪ 5 marks
- 9709/42 N25 Q5 ▪ 6 marks
- 9709/41 J25 Q1 ▪ 4 marks
- 9709/41 J25 Q6 ▪ 9 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 1

9709/41 N25 ▪ Q1 ▪ 4 marks

A car of mass 900 kg is moving along a straight horizontal road against a constant resistance to motion of 350 N. At an instant when the car is moving at 15 m s^{-1} its acceleration is 0.25 m s^{-2}.

(a) Find the driving force of the car's engine at this instant. **[2]**

(b) Find the power of the car's engine at this instant. **[2]**

Solution 1

(a)

Mark scheme

- $F - 350 = 900(0.25) = 225 \Rightarrow F = 575$ N.

Solution 1

(b)

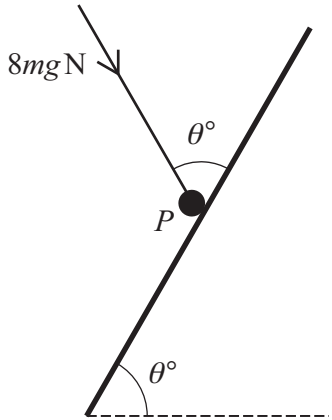
Mark scheme

- Power $= Fv = 575 \times 15 = 8625$ W.

Question 5

9709/41 N25 ▪ Q5 ▪ 6 marks

A particle P of mass m kg is in equilibrium on a rough plane inclined at an angle θ to the horizontal. The equilibrium of P is maintained by a force of magnitude $8mg$ N making an angle θ with a line of greatest slope (see diagram). The coefficient of friction between P and the plane is 0.5 and P is on the point of slipping down the plane. Find the value of θ. **[6]**



Solution 5

Mark scheme

- Perpendicular: $R = mg\cos\theta + 8mg\sin\theta$. On the point of slipping down, μR acts up: $0.5(\cos\theta + 8\sin\theta) = \sin\theta + 8\cos\theta \Rightarrow \tan\theta = 2.5 \Rightarrow \theta = 68.2$.

Question 8

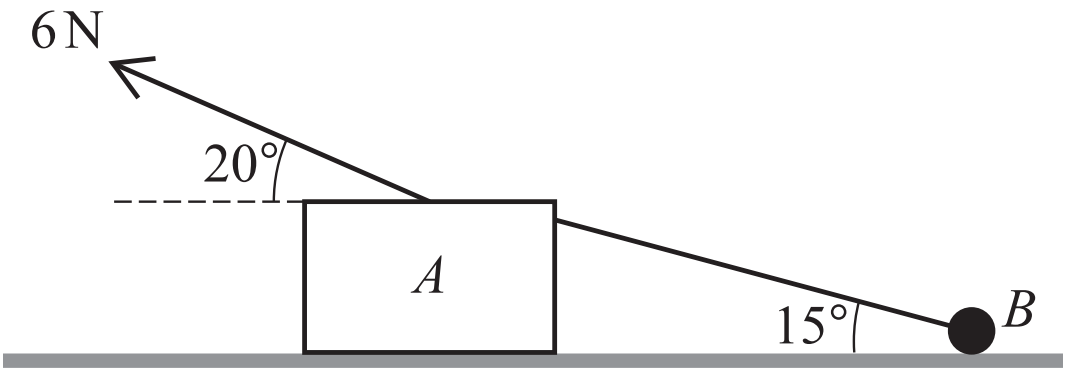
9709/41 N25 ▪ Q8 ▪ 8 marks

A block A of mass 2 kg and a particle B of mass 0.5 kg are connected by a light inextensible string inclined at 15 to the horizontal. They are pulled across a horizontal surface with acceleration 1.2 m s^{-2} by a force of magnitude 6 N, applied to A, acting at 20 above the horizontal. The contact between B and the surface is smooth and the contact between A and the surface is rough.

(a) Find the tension in the string. **[2]**

(b) Find the coefficient of friction between A and the surface. **[6]**

Question 8



Solution 8

(a)

Mark scheme

- For B (smooth surface): $T\cos 15 = 0.5(1.2) = 0.6 \Rightarrow T = 0.621$ N.

Solution 8

(b)

Mark scheme

- For A: $R = 2g + T\sin 15 - 6\sin 20 = 18.1$ N. Horizontally
  $6\cos 20 - T\cos 15 - \mu R = 2(1.2) \Rightarrow \mu = \dfrac{5.638 - 0.6 - 2.4}{18.1} = 0.146.$

Question 2

9709/42 N25 ▪ Q2 ▪ 5 marks

A railway locomotive of mass 240000 kg is towing a coach of mass 36000 kg down a hill inclined at an angle of $\sin^{-1} 0.04$ to the horizontal. The driving force produced by the locomotive is 450000 N and there are resistances to motion of 120000 N on the locomotive and 15000 N on the coach. The coupling between the locomotive and the coach is light, rigid and parallel to the hill. Find the acceleration of the locomotive and the tension in the coupling. **[5]**

Solution 2

Mark scheme

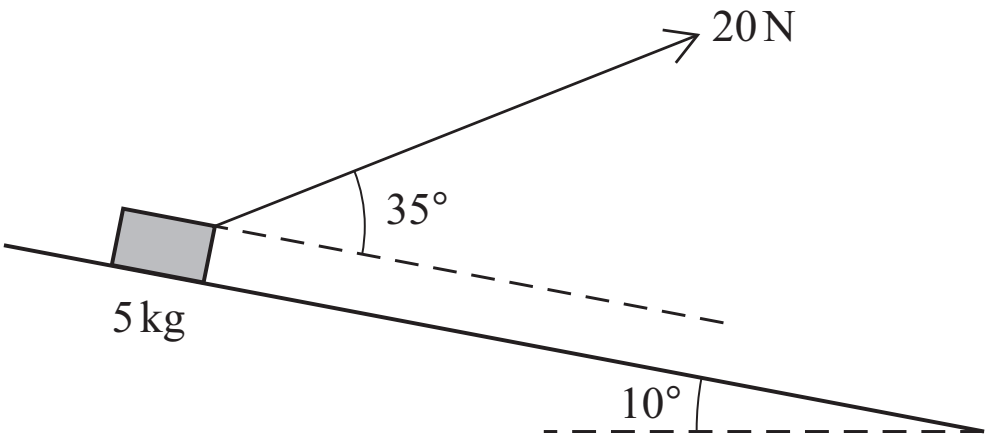
- Whole system (276000 kg):
  $450000 + 276000(10)(0.04) - 135000 = 276000a \Rightarrow a = 1.54$ m s^{-2}. Coach:
  $T + 36000(10)(0.04) - 15000 = 36000a \Rightarrow T \approx 56100$ N.

Question 5

9709/42 N25 ▪ Q5 ▪ 6 marks

A block of mass 5 kg is being pulled straight down a line of greatest slope of a rough plane by a force of magnitude 20 N. The plane is inclined at an angle of 10 to the horizontal and the 20 N force acts at an angle of 35 above the line of greatest slope of the plane (see diagram). The coefficient of friction between the block and the plane is 0.4. The speed of the block when it passes a point O is 2 m s^{-1}. Find the speed of the block when it has moved 3 m down the plane from O. **[6]**

Question 5



Solution 5

Mark scheme

- $N = 5g\cos 10 - 20\sin 35 = 37.8$ N. Net force down the plane $= 20\cos 35 + 5g\sin 10 - 0.4N = 16.38 + 8.68 - 15.11 = 9.96$ N, so $a = 1.99$ m s^{-2}. $v^2 = 2^2 + 2(1.99)(3) \Rightarrow v = 3.99$ m s^{-1}.

Question 1

9709/41 J25 ▪ Q1 ▪ 4 marks

A block of mass 12 kg is being pulled by a rope up a rough plane. The plane is inclined at an angle of 20 above the horizontal. The rope pulling the block is parallel to a line of greatest slope of the plane. The coefficient of friction between the block and the plane is 0.4. The acceleration of the block is 2 m s^{-2}. Find the tension in the rope. **[4]**

Solution 1

Mark scheme

- $R = 12g\cos 20$; N2L up the slope: $T - 0.4(12g\cos 20) - 12g\sin 20 = 12(2)$, giving $T = 110$ N (110.1).

Question 6

9709/41 J25 ▪ Q6 ▪ 9 marks

Two particles, P and Q, of masses 0.3 kg and 0.6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth pulley fixed at a point B where the inclined planes AB and BC meet. P lies on the smooth plane AB which is inclined at an angle θ to the horizontal where $\sin\theta = 0.4$. Q lies on the plane BC which is inclined at 30 to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes (see diagram). The particles are released from rest.

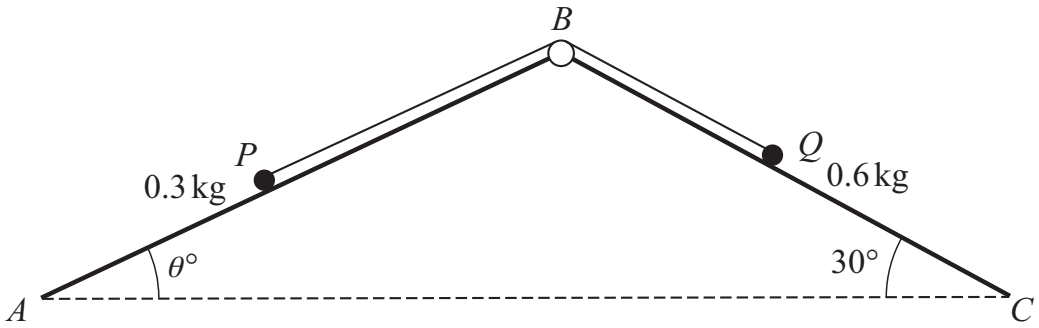
(a) It is given that the plane BC is smooth. Find the tension in the string and the acceleration of Q. **[5]**

(b) It is given instead that the plane BC is rough. The work done against the frictional force when Q moves 2 m down the plane is 1.8 J. You should assume that P does not

Question 6

reach the pulley and that Q does not reach C. Use an energy method to find the speed of Q when it has moved 2 m down the plane. **[4]**

Question 6



Solution 6

(a)

Mark scheme

- $0.6g\sin 30 - T = 0.6a$ and $T - 0.3g(0.4) = 0.3a$; adding gives $1.8 = 0.9a \Rightarrow a = 2$ m s^{-2}, and $T = 1.8$ N.

Solution 6

(b)

Mark scheme

- Energy: $\frac{1}{2}(0.9)v^2 = 0.6g(2\sin 30) - 0.3g(2)(0.4) - 1.8 = 6 - 2.4 - 1.8 = 1.8 \Rightarrow v^2 = 4 \Rightarrow v = 2$ m s^{-1}.