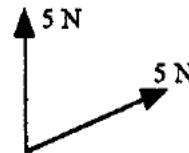


Take $g = 9.8 \text{ ms}^{-2}$ and give all answers correct to 3 significant figures where necessary.

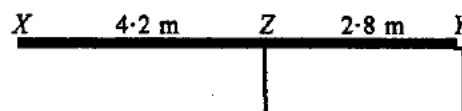
1. Two forces, both of magnitude 5 N, act on a particle in the directions with bearings 000° and 070° , as shown.



Calculate

- (a) the magnitude of the resultant force on the particle, (3 marks)
 (b) the bearing on which this resultant force acts. (2 marks)

2. A uniform plank XY has length 7 m and mass 2 kg.



It is placed with the portion ZY in contact with a horizontal surface, where $ZY = 2.8 \text{ m}$. To prevent the plank from toppling, a stone is placed on the plank at Y .

- (a) Find the smallest possible mass of the stone. (4 marks)
 (b) State, with a reason, whether your answer to part (a) would be greater or smaller if a shorter portion of the plank were in contact with the surface. (2 marks)

3. A car, of mass 1800 kg, pulls a trailer of mass 350 kg along a straight horizontal road. When the car is accelerating at 0.2 ms^{-2} , the resistances to the motion of the car and trailer have magnitudes 300 N and 100 N respectively. Find, at this time,

- (a) the driving force produced by the engine of the car, (3 marks)
 (b) the tension in the tow-bar between the car and the trailer. (4 marks)

4. A train starts from rest at a station S and accelerates at a constant rate for $2x$ seconds to a speed of $5x \text{ ms}^{-1}$. It maintains this speed until 126 seconds after it left S and then decelerates at a constant rate until it comes to rest at another station T , $20x$ seconds after it left S .

- (a) Sketch a velocity-time graph for this journey. (4 marks)

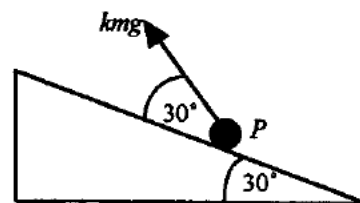
Given that the distance between S and T is 5.4 km,

- (b) show that $x^2 + 7x = 120$. (4 marks)
 (c) Find the value of x . (3 marks)

5. i and j are perpendicular unit vectors. The point A has position vector $6j$ m relative to an origin O . At time $t = 0$ a particle P starts from O and moves with constant velocity $(5i + 2j)$ ms^{-1} . At the same instant a particle Q starts from A and moves with constant velocity $4i$ ms^{-1} .
- (a) Write down the position vectors of P and of Q at time t seconds. **(3 marks)**
- (b) Show that the distance d m between P and Q at time t seconds is such that
- $$d^2 = 5t^2 - 24t + 36. \quad \text{(5 marks)}$$
- (c) Find the value of t for which d^2 is a minimum. **(3 marks)**
- (d) Hence find the minimum distance between P and Q , and state the position vector of each particle when they are closest together. **(4 marks)**

6. A , B and C are three small spheres of equal radii and masses $2m$, m and $5m$ respectively. They are placed in a straight line on a smooth horizontal surface. A is projected with speed 6 ms^{-1} towards B , which is at rest. When A hits B it exerts an impulse of magnitude $8m$ Ns on B .
- (a) Find the speed with which B starts to move. **(2 marks)**
- (b) Show that the speed of A after it collides with B is 2 ms^{-1} . **(3 marks)**
- After travelling 3 m, B hits C , which is then travelling towards B at 2.2 ms^{-1} . C is brought to rest by this impact.
- (c) Show that the direction of B 's motion is reversed and find its new speed. **(3 marks)**
- (d) Find how far B now travels before it collides with A again. **(6 marks)**
- (e) State a modelling assumption that you have made about the spheres. **(1 mark)**

7. A particle P , of mass m , is in contact with a rough plane inclined at 30° to the horizontal as shown. A light string is attached to P and makes an angle of 30° with the plane. When the tension in this string has magnitude kmg , P is just on the point of moving up the plane.



- (a) Show that μ , the coefficient of friction between P and the plane, is $\frac{k\sqrt{3}-1}{\sqrt{3}-k}$. **(7 marks)**
- (b) Given further that $k = \frac{3\sqrt{3}}{7}$, deduce that $\mu = \frac{\sqrt{3}}{6}$. **(3 marks)**
- The string is now removed.
- (c) Determine whether P will move down the plane and, if it does, find its acceleration. **(5 marks)**
- (d) Give a reason why the way in which P is shown in the diagram might not be consistent with the modelling assumptions that have been made. **(1 mark)**