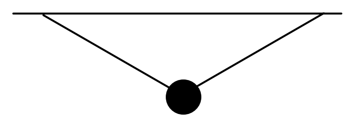
MECHANICS (C) UNIT 1 TEST PAPER 1

Take $g = 9{\cdot}8$ ms^{-2} and give all answers correct to 3 significant figures where necessary.

1. A particle moves in a straight line from A to B in 5 seconds. At time t seconds after leaving A, the velocity of the particle is $(32t - 3t^2)$ ms^{-1}.
   (i) Calculate the straight-line distance AB. [4]
   (ii) Find the magnitude of the acceleration of the particle when $t = 3$. [3]

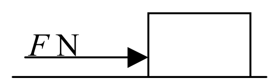
2. A small ball P, of mass 0·8 kg, is suspended from a horizontal ceiling by two light inextensible strings. P is in equilibrium under gravity with both strings inclined at 30^0 to the horizontal, as shown.



   (i) Find the tension, in N, in either string. [3]
   (ii) Calculate the magnitude of the least **horizontal** force that must be applied to P in this position to cause one string to become slack.

3. A particle P moves in a straight line through a fixed point O with constant acceleration a ms^{-2}. 3 seconds after passing through O, P is 6 m from O.
   After a further 6 seconds, P has travelled a further 33 m in the same direction.
   (i) Calculate the value of a. [5]
   (ii) Calculate the speed with which P passed through O. [2]

4. A force of magnitude F N is applied to a block of mass M kg which is initially at rest on a horizontal plane. The block starts to move with acceleration 3 m s^{-2}. Modelling the block as a particle,



   (i) if the plane is smooth, find an expression for F in terms of M. [2]
   If the plane is rough, and the coefficient of friction between the block and the plane is μ,
   (ii) express F in terms of M, μ and g. [2]
   (iii) Calculate the value of μ if $F = \frac{1}{2}Mg$. [3]

5. Two smooth spheres A and B, of masses 60 grams and 90 grams respectively, are at rest on a smooth horizontal table. A is projected towards B with speed 4 ms–1 and the particles collide. After the collision, A and B move in the same direction as each other with speeds u ms–1 and $6u$ ms^{-1} respectively.
   (i) Calculate the value of u. [3]
   A and B are now replaced in their original positions and projected towards each other with speeds 2 ms–1 and 8 ms–1 respectively. They collide again, after which A moves with speed 7 ms^{-1}, its direction of motion being reversed.
   (ii) Find the speed of B after this collision and state whether its direction of motion has been reversed. [5]

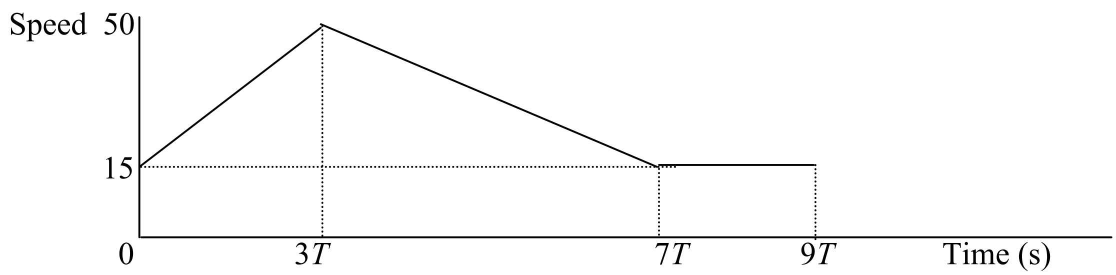
6. Two metal weights A and B, of masses 2·4 kg and 1·8 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley so that the string hangs vertically on each side. The system is released from rest with the string taut.

(i) Calculate the acceleration of each weight and the tension in the string. [6]

A is now replaced by a different weight of mass m kg, where $m < 1·8$, and the system is again released from rest. The magnitude of the acceleration has half of its previous value.

(ii) Calculate the value of m. [6]

7. The diagram shows the speed-time graph for a particle during a period of $9T$ seconds.



(i) If $T = 5$, find

(a) the acceleration for each section of the motion, [2]

(b) the total distance travelled by the particle. [2]

(ii) Sketch, for this motion, (a) an acceleration-time graph, [2]

(b) a displacement-time graph. [2]

(iii) Calculate the value of T for which the distance travelled over the $9T$ seconds is 3·708 km. [4]

MECHANICS 1 (C) TEST PAPER 1 : ANSWERS AND MARK SCHEME

1. (i) $AB = \int_0^5 \text{v}dt = [16t^2 - t^3] = 400 - 125 = 275$ m M1 A1 M1 A1

(ii) $a = 32 - 6t$ $t = 3 : a = 32 - 18 = 14\ \text{ms}^{-2}$ B1 M1 A1 7

2. (i) $0{\cdot}8g = 2T \sin 30^0$ $T = 0{\cdot}8g = 7{\cdot}84$ N B1 M1 A1

(ii) $F = T \cos 30^0$, $0{\cdot}8\text{g} = T \sin 30^0$ $F = 0{\cdot}8\text{g}\sqrt{3} = 13.6$ N B1 B1 M1 A1 7

3. (i) $s = ut + \frac{1}{2}at^2$: $3u + 4{\cdot}5a = 6$, $9u + 40{\cdot}5a = 39$ M1 A1 A1

$21 = 27a$ $a =$ ms^{-2} M1 A1

(ii) $u = \frac{5}{6}\ \text{ms}^{-1}$ M1 A1 7

4. (i) $F = Ma$, so $F = 3M$ M1 A1

(ii) $F - \mu Mg = 3M$ $F = M(3 + \mu g)$ M1 A1

(iii) $3 + \mu g =$ g $\mu = \frac{1}{2} - {}^3/_g = 0{\cdot}194$ M1 A1 A1 7

5. (i) $60 \times 4 = 60u + 90 \times 6u$ $600u = 240$ $u = 0{\cdot}4$ M1 A1 A1

(ii) $60(2) + 90(-8) = 60(-7) + 90v_B$ M1 A1

$-180 = 90v_B$ $v_B = -2$, so speed = 2 ms^{-1}, direction unchanged M1 A1 A1 8

6. (i) $F = ma$ for each : $2{\cdot}4g - T = 2{\cdot}4a$, $T - 1{\cdot}8g = 1{\cdot}8a$ M1 A1 A1

Add : $0{\cdot}6g = 4{\cdot}2a$ $a = \frac{1}{7}g = 1{\cdot}4\ \text{ms}^{-1}$ $T = 20{\cdot}2$ N M1 A1 A1

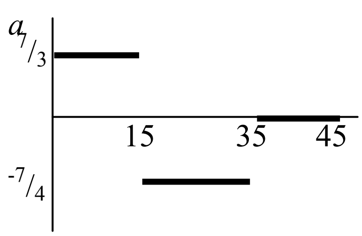
(ii) Now $1{\cdot}8g - T = 1{\cdot}8(0{\cdot}7)$ so $T = 16{\cdot}38$, and $T - mg = m(0{\cdot}7)$ M1 A1 M1 A1

$10{\cdot}5m = 16{\cdot}38$ $m = 1{\cdot}56$ M1 A1 12

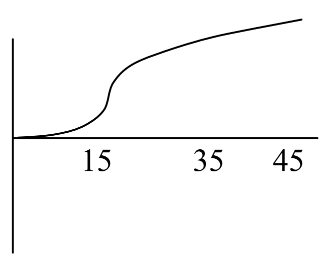
7. (i) (a) ${}^7/_3\ \text{ms}^{-2}$, $-{}^7/_4\ \text{ms}^{-2}$, $0\ \text{ms}^{-2}$ B2 (–1 each error)

(b) $45 \times 15 + \frac{1}{2} \times 35^2 = 1287{\cdot}5$ m M1 A1

(ii) (a)



(b)



B2 B2

(iii) $15 \times 9T + 35 \times 3{\cdot}5T = 3708$ $257{\cdot}5T = 3708$ $T = 14{\cdot}4$ M1 A1 M1 A1 12