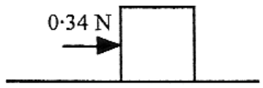
MECHANICS (C) UNIT 1 **TEST PAPER 6**

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

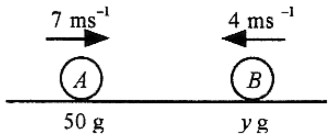
1. A small box, of mass 0·5 kg, is initially at rest on a horizontal table-top. A horizontal force of magnitude 0·34 N is applied to the box as shown. Modelling the box as a particle, find the acceleration with which the box starts to move if



(i) the contact between the box and the table is smooth, [2]

(ii) the contact is rough, the coefficient of friction being 0·05. [3]

2. Two particles *A* and *B*, of masses 50 grams and *y* grams, are moving in the same straight line, in opposite directions, with speeds 7 ms^{-1} and 4 ms^{-1} respectively, and collide. Find the value of *y* in each of the following separate cases :



(i) after impact the particles move together with speed 2·25 ms^{-1}; [3]

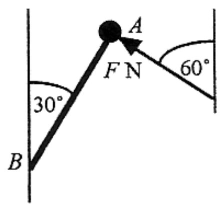
(ii) after impact the particles move in opposite directions with speed 5 ms^{-1}. [3]

3. A particle passes through a point *O* with speed 9 ms^{-1} and moves in a straight line with constant acceleration 3·6 ms^{-2} for *t* seconds until it reaches the point *P*. The acceleration is then reduced to 2 ms^{-2} and this is maintained for another *t* seconds until the particle passes the point *Q* with speed 16 ms^{-1}. Calculate

(i) the time taken by the particle to travel from *O* to *Q*, [4]

(ii) the distance *OQ*. [3]

4. A lump of clay, of mass 0·8 kg, is attached to the end *A* of a light rod *AB*, which is pivoted at the other end *B* so that it can rotate smoothly in a vertical plane. A force is applied to *A* at an angle of 60° to the vertical, as shown, the magnitude *F* N of this force being just enough to hold the lump of clay in equilibrium with *AB* inclined at an angle of 30° to the upward vertical. Making suitable modelling assumptions, find



(i) the value of *F*, [5]

(ii) the magnitude of the force in the rod *AB*. [2]

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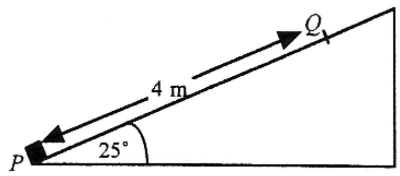
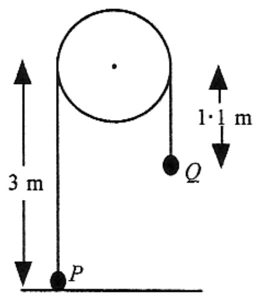
5. A particle P moves in a straight line so that its displacement s metres from a fixed point O at time t seconds is given by the formula $s = t^3 - 7t^2 + 8t$.
   (i) Find the values of t when the velocity of P equals zero, and briefly describe what is happening to P at these times. [5]
   (ii) Find the distance travelled by P between the times $t = 3$ and $t = 5$. [3]
   (iii) Find the value of t when the acceleration of P is $-2\ \text{ms}^{-2}$. Briefly explain the significance of a negative acceleration at this time. [3]

6. 

A small stone, of mass 0·2 kg is projected with speed $7\ \text{ms}^{-1}$ from P, the bottom of a rough plane inclined at 25° to the horizontal, and moves up a line of greatest slope of the plane until it comes to instantaneous rest at Q, where $PQ = 4$ m.
   (i) Show that the deceleration of the stone as it moves up the plane has magnitude $\frac{49}{8}\ \text{ms}^{-2}$. [2]
   (ii) Find the coefficient of friction between the stone and the plane, [4]
   (iii) Find the speed with which the stone returns to P. [4]
   (iv) Name one force which you have ignored in your mathematical model, and state whether the answer to (iii) would be larger or smaller if that force were taken into account. [2]

7. 

A particle P, of mass 4 kg, rests on horizontal ground and is attached by a light, inextensible string to another particle Q of mass 4·5 kg. The string passes over a smooth pulley whose centre is 3 m above the ground. Initially Q is 1·1 m below the level of the centre of the pulley. The system is released from rest in this position.
   (i) Find the acceleration of the two particles. [4]
   (ii) Find the speed with which Q hits the ground. [2]

Given that, while the string is slack, Q does not rebound from the ground and P does not hit the pulley, find
   (iii) the time for which P continues to rise, [2]
   (iv) the speed with which Q leaves the ground when the string again becomes taut. [4]

MECHANICS 1 (C) TEST PAPER 6 : ANSWERS AND MARK SCHEME

1.	(i) $0{\cdot}34 = 0{\cdot}5a$ $\quad a = 0{\cdot}68 \text{ ms}^{-2}$	M1 A1	
	(ii) $R = 0{\cdot}5g$ so frictional force $= 0{\cdot}05R = 0{\cdot}245$ N	M1	
	Acc. force $= 0{\cdot}095$ N, so $a = 0{\cdot}19 \text{ ms}^{-2}$	A1 A1	5
2.	(i) Momentum : $7 \times 50 - 4y = 2{\cdot}25(50 + y)$ $\quad 6{\cdot}25y = 237{\cdot}5$ $\quad y = 38$	M1 A1 A1	
	(ii) Momentum : $7 \times 50 - 4y = -5 \times 50 + 5y$ $\quad 9y = 600$ $\quad y = 66\frac{2}{3}$	M1 A1 A1	6
3.	(i) At P, $v = 9 + 3{\cdot}6t$ $\quad$ At Q, $v = 9 + 3{\cdot}6t + 2t = 9 + 5{\cdot}6t$	M1 A1	
	$9 + 5{\cdot}6t = 16$ $\quad 5{\cdot}6t = 7$ $\quad t = 1{\cdot}25$ $\quad O$ to Q : 2·5 s	M1 A1	
	(ii) $\frac{1}{2} \times 1{\cdot}25 \times (9 + 13{\cdot}5 + 13{\cdot}5 + 16) = 32{\cdot}5$ m	M1 A1 A1	7
4.	(i) Resolve : $F \sin 60° = T \sin 30°$, $\quad F \cos 60° + T \cos 30° = 0{\cdot}8g$	M1 A1 A1	
	Hence $F\sqrt{3} = T$, $\quad F + T\sqrt{3} = 1{\cdot}6g$ $\quad 4F = 1{\cdot}6g$ $\quad F = 3{\cdot}92$ N	M1 A1	
	(ii) $T = 3{\cdot}92\sqrt{3} = 6{\cdot}79$ N	M1 A1	7
5.	(i) $v = 3t^2 - 14t + 8 = (3t - 2)(t - 4)$ $\quad v = 0 : t = \frac{2}{3},\ t = 4$	M1 A1 M1 A1	
	P is turning round (changing direction)	A1	
	(ii) $s(3) = -12$, $s(4) = -16$, $s(5) = -10$, so dist $= 4 + 6 = 10$ m	M1 A1 A1	
	(iii) $a = 6t - 14$ $\quad a = -2$ when $t = 2$	M1 A1	
	Negative acceleration acting on negative velocity, so speeding up	B1	11
6.	(i) $0 = 7^2 - 2a(4)$ $\quad a = \frac{49}{8} \text{ ms}^{-2}$	M1 A1	
	(ii) Acc down plane $= g \sin 25° + \mu g \cos 25° = 9{\cdot}8(\sin 25° + \mu \cos 25°)$	M1 A1	
	Hence $\sin 25° + \mu \cos 25° = 0{\cdot}625$ $\quad \mu = 0{\cdot}223$	M1 A1	
	(iii) Now down plane, acc. $= g \sin 25° - \mu g \cos 25° = 0{\cdot}220g$	M1 A1	
	$v^2 = 0 + 2(4)(0{\cdot}220g) = 17{\cdot}27$ $\quad v = 4{\cdot}16 \text{ ms}^{-1}$	M1 A1	
	(iv) Air resistance, which would make the answer smaller	B1 B1	12
7.	(i) $4{\cdot}5g - T = 4{\cdot}5a$, $\quad T - 4g = 4a$	B1 B1	
	Add : $0{\cdot}5g = 8{\cdot}5a$ $\quad a = 0{\cdot}576 \text{ ms}^{-2}$	M1 A1	
	(ii) $v^2 = 2as = 2(0{\cdot}576)(1{\cdot}9) = 2{\cdot}191$ $\quad v = 1{\cdot}48 \text{ ms}^{-1}$	M1 A1	
	(iii) Under gravity P rises for t s where $0 = 1{\cdot}48 - 9{\cdot}8t$ $\quad t = 0{\cdot}151$	M1 A1	
	(iv) P returns to 1·9 m above ground with speed $1{\cdot}48 \text{ ms}^{-1}$	B1	
	Momentum conserved : $4(1{\cdot}48) + 4{\cdot}5(0) = 8{\cdot}5v$	M1 A1	
	$v = 0{\cdot}697 \text{ ms}^{-1}$	A1	12