2018-2019 Term 2

PHYS1001 Essential Physics

Mid-term Test

Time allowed: 55 minutes

Please answer **all** five questions. Each question carries the same weight. Support your answers with explanation.

Equations for linear motion under constant acceleration.

$$v = u + at$$

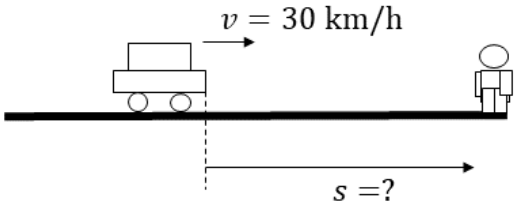
$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \frac{(u+v)}{2}t$$

Acceleration due to gravity	$g = 9.81$ ms^{-2} (close to earth)
Universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2}kg^{-2}

1. (a) A car is initially moving at a velocity of 30 km/h. The driver applies the brake and the car decelerates at 3 m/s^2. Calculate the displacement of the car before the car finally stops. (15 marks)



(b) Suppose the reaction time of the driver is 0.2 s (i.e. the driver can only apply the brake 0.2 s after he sees the pedestrian crossing the road). Assume the initial velocity of the car is 30 km/h, what is the minimum initial distance between the driver and the pedestrian so that the driver has enough time to react and to avoid hitting the pedestrian? (5 marks).

Answer:

(a) $u = 30\frac{\text{km}}{\text{h}} = \frac{\frac{30000}{3600}\text{m}}{\text{s}} = 8.33$ m/s

$$u = 8.33\frac{\text{m}}{\text{s}}, \qquad a = -3, v = 0, s = ?$$

$$v^2 = u^2 + 2as$$

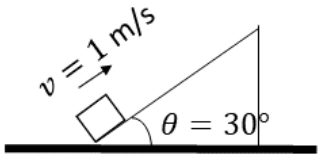
$$0^2 = (8.33)^2 + 2(-3)s$$

$$s = 11.56 \text{ m}$$

(b) $s = 11.56 + 8.33 \times 0.2 = 13.23$ m

PLEASE TURN OVER

2. A 2-kg block is put on an inclined plane which is fixed to the ground. The angle between the inclined plane and the horizontal axis is 30°. The block is given an initial velocity of 1 m/s upwards along the plane. It then moves up along the inclined plane.



(a) Draw a force diagram for the block when the block is on the inclined plane (5 marks).
(b) Calculate the values of all forces in the force diagram in part (a) (5 marks).
(c) Calculate the maximum displacement of the block along the inclined plane (10 marks).

Answer:

(a)

(b) $W = mg = (2)(9.81) = 19.62$ N

Normal reaction $= mg\cos 30^\circ = 16.99$ N

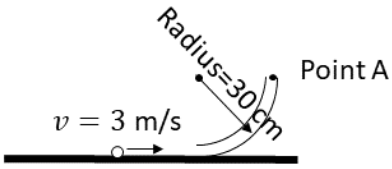
(c) $s = ?, a = -g\sin 30^\circ = -4.905, u = 1$

$$0^2 = (1)^2 + 2(-4.905)s$$

$$s = 0.10 \text{ m}$$

PLEASE TURN OVER

3. A table tennis ball is given an initial horizontal velocity of 3 m/s. The ball moves in a smooth circular hollow tube that makes an arc with a radius of 30 cm as shown in the figure. Point A is the highest point of the tube.



(a) Can the ball reach point A? Explain your answer (10 marks)

(b) Describe the subsequent motion of the ball after the ball leaves its initial location. [Please also describe qualitatively how the velocity of the ball changes during its motion.] (10 marks)

Answer:

(a) By conservation of energy

$$\frac{1}{2}mv^2 = mgh$$

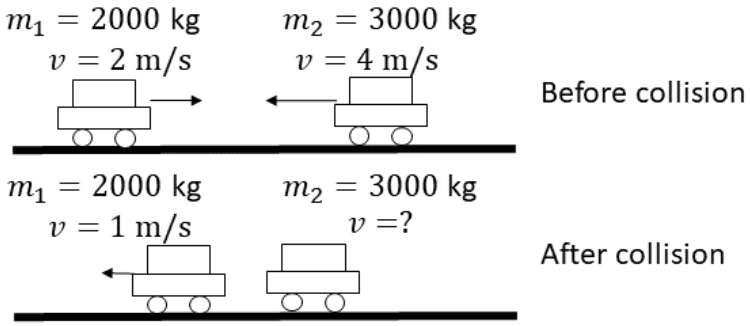
$$h = \frac{1}{2g}v^2$$

$$h = \frac{1}{2(9.81)}(3)^2$$

$$h = 0.46 \text{ m}$$

(b) The ball moves through the tube, leaves the tube at point A and moves upwards. It reaches the highest point which is at a height 0.46 m above ground before dropping back to point A again. The ball then moves through the hallow tube and finally returns to the starting point. At that point the velocity of the ball is 3 m/s to the left. The ball then moves to the left.

4. A car with mass 2000 kg is initially moving at a speed of 2 m/s to the right. It collides head-on with a second car with mass 3000 kg initially moving with a speed of 4 m/s as shown in the figure below. After the collision, the first car recoils at a speed of 1 m/s.



(a) Calculate the final velocity of the second car (10 marks).

(b) Calculate the total mechanical energy of the two cars before and after collision. Is the total mechanical energy conserved in this case? (10 marks)

Answer:

(a) By conservation of linear momentum

$$m_1 v_{1,init} + m_2 v_{2,init} = m_1 v_{1,final} + m_2 v_{2,final}$$
$$(2000)(2) + (3000)(-4) = (2000)(-1) + (3000) v_{2,final}$$
$$v_{2,final} = -2 \text{ m/s}$$

(b) Initial total K.E. of the two cars $= \frac{1}{2} m_1 {v_{1,init}}^2 + \frac{1}{2} m_2 {v_{2,init}}^2 = \frac{1}{2}(2000)(2)^2 + \frac{1}{2}(3000)(4)^2 = 28000$ J

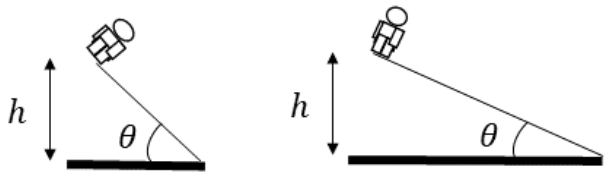
Final total K.E. of the two cars $= \frac{1}{2} m_1 {v_{1,final}}^2 + \frac{1}{2} m_2 {v_{2,final}}^2 = \frac{1}{2}(2000)(1)^2 + \frac{1}{2}(3000)(2)^2 = 7000$ J

Total mechanical energy of the system is not conserved. Part of the energy is converted to thermal energy and sound energy.

5. (a) State whether the following statement is always correct or not. Give an explanation to support your argument (10 marks).

"The velocity vector of a moving object has to be in the same direction as the acceleration vector of the same object."

(b) A skier is initially at rest and moves down the slope from the same height h as shown in the figure below. Ignoring friction, determine the time it takes the skier to reach the ground in terms of h and θ. Sketch a graph showing how this time varies with the inclination angle of the plane (10 marks).



Answer:

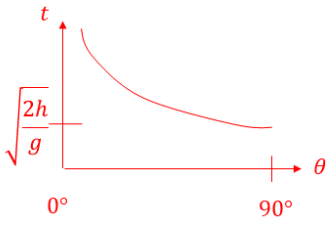
(a) False. Suppose a ball is thrown upwards. In the journey when the ball moves upwards, the acceleration points downwards while the velocity vector points upwards.

(b) $u = 0,\ s = \frac{h}{\sin\theta}, a = -g\sin\theta\ , t = ?$

$$s = ut + \frac{1}{2}at^2$$

$$\frac{-h}{\sin\theta} = \frac{1}{2}(-g\sin\theta)t^2$$

$$t = \sqrt{\frac{2h}{g}}\frac{1}{\sin\theta}$$



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