2017-2018 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.

$$v = u + at$$

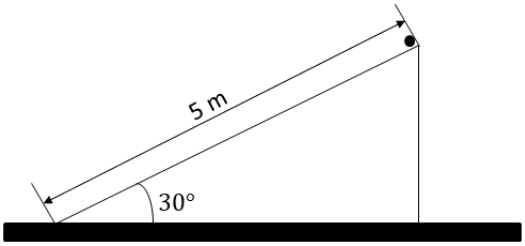
$$s = ut + \frac{1}{2}at^2$$

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

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

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 10 m/s. It undergoes a constant deceleration of 6 m/s^2. Calculate the displacement of the car before the car comes to a complete rest. (10%)
(b) A bead with mass 2 kg is put on a rough inclined plane that is fixed to the ground at an angle of 30°. A constant frictional force of 1 N exists between the bead and the surface.



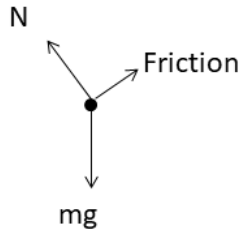
(i) Draw a force diagram for the bead (3%).
(ii) If the incline plane has a total length of 5 m, calculate the time needed for the bead to reach the bottom of the incline. (7%)

Answer:

(a) $u = 10, a = -6, s = ?, v = 0$

$$v^2 = u^2 + 2as$$
$$(0)^2 = (10)^2 + 2(-6)s$$
$$s = 8.3 \text{ m}$$

(b)(i)



(ii) $F_{net} = ma$

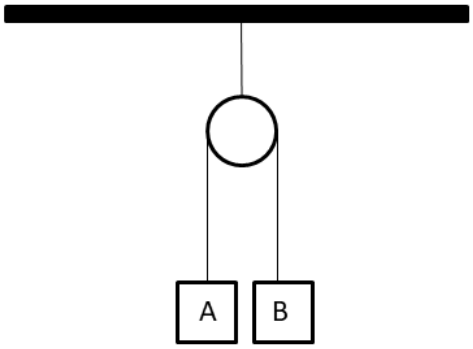
$$mg \sin 30° - \text{friction} = ma$$

$$(2)(9.81)\sin 30° - 1 = (2)a$$
$$a = 4.405 \text{ m/s}^2$$
$$s = 5, a = 4.405, u = 0, t = ?$$

$$s = ut + \frac{1}{2}at^2$$
$$5 = \frac{1}{2}(4.405)t^2$$
$$t = 1.51 \text{ s}$$

PLEASE TURN OVER

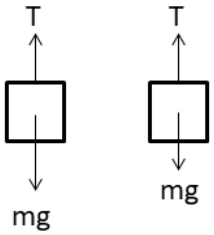
2. Block A of mass 3 kg is connected to a light inextensible string that passes over a massless pulley to block B of mass 2 kg as shown in the figure below. The two blocks are released from rest.



(a) Draw a force diagram for block A and another one for block B. (6%)
(b) Calculate the acceleration of block A. (7%)
(c) Calculate the tension in the string connecting the ceiling and the pulley. (7%)

Answer:

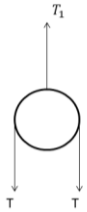
(a)



(b) $$m_A g - T = m_A a$$
$$T - m_B g = m_B a$$
$$m_A g - m_B g = (m_A + m_B)a$$
$$a = 1.96 \text{m/s}^2$$

(c) $(3)(9.81) - T = (3)(1.96)$

$$T = 23.6 \text{ N}$$



$$T_1 = 2T = 47.2 \text{ N}$$

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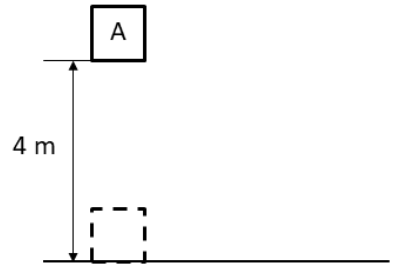
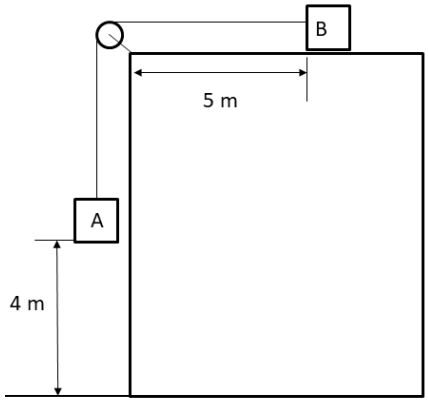
3. A block with mass 2 kg is released from rest from a height of 4 m.



(a) Using the principle of conservation of energy, calculate the speed of the block right before it reaches the ground. (10%)

(b) Block B, which has a mass 4 kg, is placed on a smooth horizontal surface. Block A which has a mass of 2 kg is connected to block B by a light inextensible string that passes over a massless pulley as shown in the figure below. Initially the whole system is at rest while block A is at a height of 4 m.



Using the principle of conservation of energy, calculate the speed of block A right before it reaches the ground. (10%)

Answers:

(a) $mgh = \frac{1}{2}mv^2$

$$v = \sqrt{2gh}$$

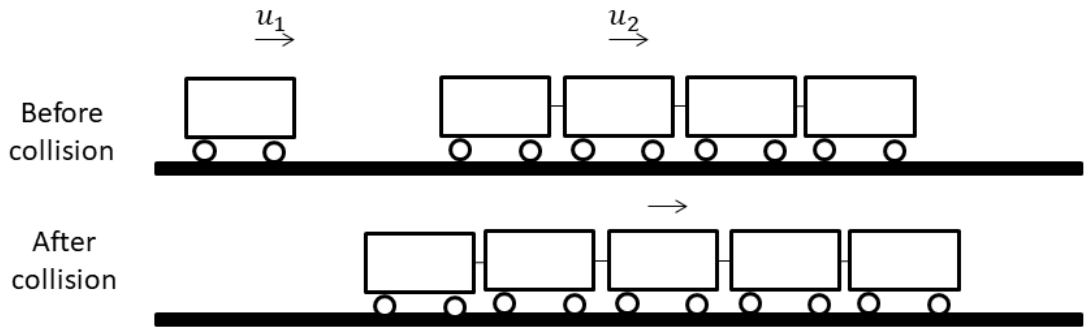
$$v = 8.86 \text{ m/s}$$

(b) $$m_A gh = \frac{1}{2}m_A v^2 + \frac{1}{2}m_B v^2$$

$$v = 5.1 \text{ m/s}$$

PLEASE TURN OVER

4. A rail car of mass 30000 kg moves with a speed of 3 m/s to the right. It collides and couples with four other coupled rail cars, each of the same mass as the single car. The four coupled rail cars move in the same direction with an initial speed of 1 m/s to the right.



(a) Calculate the speed of the five cars after collision. (10%)
(b) Calculate the amount of mechanical energy loss in the process. (10%)

Answers:

(a) $$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$(30000)(3) + (4)(30000)(1) = (30000 + (4)(30000))v$$
$$v = 1.4 \text{ m/s}$$

(b) Initial K.E.$= \frac{1}{2}(30000)(3)^2 + \frac{1}{2}(4)(30000)(1)^2 = 195000$ J

Final kinetic energy$= \frac{1}{2}\big((5)(30000)\big)(1.4)^2 = 147000$ J

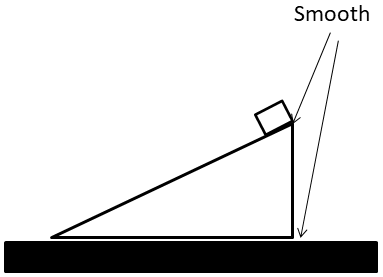
Mechanical energy loss$= 195000 - 147000 = 48000$ J

PLEASE TURN OVER

5. (a) State whether the following statements are always correct or not. Give an explanation to support your argument.

A man is standing in a lift. The lift is moving upwards but decelerating (i.e. accelerating downwards). The man feels heavier than that when the lift is at rest because the weight of the man is larger when the lift is accelerating downwards. (10%)

(b) A block is placed on a smooth incline wedge as shown in the figure below. It is known that there is no friction between the plane and the ground. Explain qualitatively the subsequent motion of the block and the wedge (10%).



Answers:

(a) False. The net force on the man is downwards. The normal reaction force is smaller than the weight. The man feels he is lighter. Also the weight of the man is always given by mg.

(b) When the block is released, it slides down the wedge. As there is no horizontal force acting on the system consisting the block and the wedge, the wedge moves to the right. The velocity of the block increases along the wedge. The velocity of the wedge also increases to the right.

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