The Copperbelt University (CBU)

School of Mathematics and Natural Sciences

PH 110 Test 1 – Deferred **September 2020** **Online**

Name: ________________________________ **Id Number:**________________

Group: __________________________

Use gravitational acceleration g = 9.82 m/s^2 where not specified.

ANSWER ALL QUESTIONS

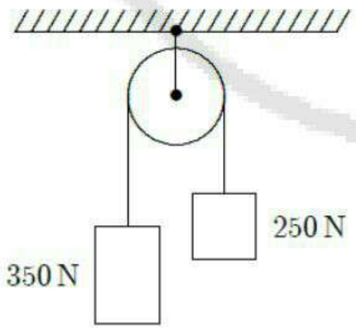
1. In a freefall vertical motion where the time of ascent is equal to the time of descent, use equations to show that the initial velocity at firing upwards is equal to the final velocity at landing. [10 marks]

2. Explain why your weight may be different when you are in Kitwe compared to when you are in Gwembe valley even when your mass is the same. [10 marks]

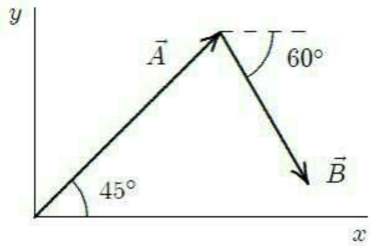
3. Explain with the use of equations why a pistol fired from the clouds 10 km away is capable of killing a person on the ground compared to when it is fired horizontally over same distance. [10 marks]

4. A 1000 kg elevator is rising and its speed is increasing at 8 m/s^2. Calculate the tension of the cable holding the elevator [10]

5. Two blocks, weighing 350 N and 250 N, respectively, are connected by a string that passes over a massless pulley as shown. Calculate the tension in the string and explain why the tension on the left is not greater than the tension on the right side. [10 marks]



6. In the diagram, $\vec{A}$ has magnitude 12 N and $\vec{B}$ has magnitude 8 N. Calculate the x component of $\vec{A} + \vec{B}$ [15 marks]



7. A projectile is fired at an angle of 65 degrees to the horizontal with initial velocity of 100 m/s. Find:

   i. Time of ascent [5 marks]
   ii. Time of flight [5 marks]
   iii. Maximum height reached [5 marks]
   iv. Range [5 marks]
   v. Maximum possible range [5 marks]

8. Find the center of mass of a system of particles in the Cartesian coordinates for Mass (x, y, z) as follows: 10 kg (-2, 4, 2), 5 kg (6, 8, 2), and 15 kg (0, -7, 2). [10 marks]

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PH110 DEFERRED TEST 1

SOLUTIONS

(1) Using the equations of motion

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

For upward motion: $v = 0, a = -g$

$\Rightarrow 0 = u - gt \Rightarrow u = gt$ — (1)

or using the other equation:

$0 = u^2 - 2gs \Rightarrow u^2 = 2gs$ — (2)

For downward motion: $u = 0, a = +g$

$\Rightarrow v = 0 + gt \Rightarrow v = gt$ — (3)

Comparing eqn (1) and (3) we see the two are equal

or $v^2 = 0 + 2gs \Rightarrow v^2 = 2gs$ — (4). Eqn (2) = eqn (4)

Hence $v = u$

(2) Because of the difference in altitude or height above sea level. Kitwe is higher above sea level compared to Gwembe (valley)

Gravitational force decreases with increase in height above sea level.

$$F_G = \frac{GMm}{h^2}$$, where h is height.

(3) <u>Horizontal scenerio</u>

- Horizontal velocity is constant
- Distance travelled (Range) is likely less than 10 Km
- using $v^2 = u^2 + 2as$, $a = 0$
  $\Rightarrow v^2 = u^2 \Rightarrow v = u$

<u>Vertical scenerio</u>

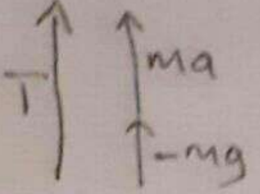
- The vertical velocity keeps increasing as the bullet travels downwards.
- Final velocity is greater than initial velocity
- using $v^2 = u^2 + 2as$
  $\Rightarrow v^2 = u^2 + 2g(10{,}000)$

  $\underline{\underline{v > u}}$

(4)

$$ma_y = \sum f_y$$

Taking forces in the +ve y-direction as positive and those in the -ve y-direction as negative



$$ma = T - mg$$

$$\Rightarrow T = ma + mg$$

$$= m(a+g)$$

$$= 1000(8 + 9.82)$$

$$= 1000(17.82)$$

$$\therefore T = 17{,}820\,N$$

(5) We have 3 main equs.:

$$m_1 a_1 = T - m_1 g$$

$$m_2 a_2 = T - m_2 g$$

$$a_1 = -a_2$$

Solving simulteneously gives

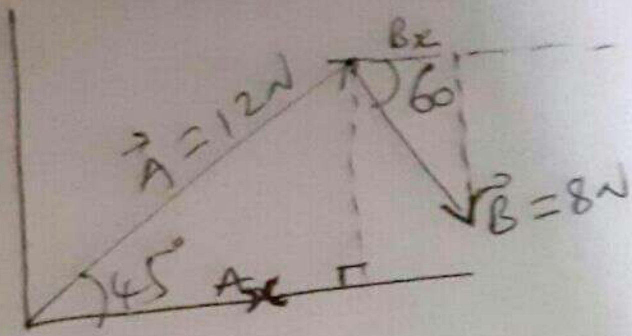
$$T = \left(\frac{2m_2 m_1}{m_2 + m_1}\right) g$$

$$= \frac{2(350 \times 250)\,9.82}{(350 + 250)}$$

$$= 2{,}864.2\,N$$

- The tension is the same string and experience the same acceleration.

(b)



use SOHCAHTOA

$\cos 45 = \frac{A_x}{A} \Rightarrow A_x = A\cos 45 = 12 * 0.7071067$

$A_x = 8.485$

$\cos 60 = \frac{B_x}{B} \Rightarrow B_x = B\cos 60 = 8 * 0.5$

$B_x = 4$

Resultant in the x-direction is $A_x + B_x = 8.485 + 4$

$= 12.485\,N$

(7) main equations:

$u_x = u\cos 65 \;;\; u_y = u\sin 65$

(i) $v_y = u_y + a_y t$, but $v_y = 0, a_y = -g$

$\Rightarrow 0 = u\sin 65 - gt$

$\Rightarrow -u\sin 65 = -gt$

$\Rightarrow t = \frac{u\sin 65}{g} = \frac{100(0.90631)}{9.82} = 9.229$

$\therefore t = 9.23\,s$

(ii) Time of flight is twice time of ascent:

$T = 2t = 2 * 9.229 = 18.458$

$\therefore T = 18.46\,s$

(iii) $v_y^2 = u_y^2 + 2a_y s_y \;;\; v_y = 0, a_y = -g, s_y = H$

$\Rightarrow 0 = u_y^2 - 2gH$

$\Rightarrow H = \frac{u_y^2}{2g} = \frac{(u\sin 65)^2}{2 * 9.82} = 418.22\cancel{4}95$

$\therefore H = 418.22\,m$

(iv) $v_x^2 = u_x^2 + 2a_x s_x \;;\; v_x = u_x, a_x = 0 \;;\; s_x = R$

use $s = \left(\frac{u+v}{2}\right)T \Rightarrow s_x = \left(\frac{u_x + v_x}{2}\right)T$

$\Rightarrow R = \frac{2u_x}{2}T = u_x T = (42.2618)\,18.46$

$\therefore R = 780.15\,m$

(v) maximum possible range occurs at $\theta = 45°$, hence

$R_{max} = u\cos 45° T = 1305.32\,m$

(8) Centre of mass (CM) is given by

$$CM = (x_{cm}, y_{cm}, z_{cm})$$

where $x_{cm} = \sum \frac{m_i x_{icm}}{m_i} = \frac{m_1 x_{1cm} + m_2 x_{2cm} + m_3 x_{3cm}}{(m_1 + m_2 + m_3)}$

$$y_{cm} = \sum \frac{m_i y_{icm}}{m_i}$$

$$z_{cm} = \sum \frac{m_i z_{icm}}{m_i}$$

$$\Rightarrow x_{cm} = \frac{10(-2) + 5(6) + 15(0)}{10 + 5 + 15} = \frac{1}{3} = 0.33$$

$$y_{cm} = \frac{10(4) + 5(8) + 15(-7)}{10 + 5 + 15} = -0.83$$

$$z_{cm} = \frac{10(2) + 5(2) + 15(2)}{30} = 2$$

$$\therefore CM = (0.33, -0.83, 2)$$

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