THE COPPERBELT UNIVERSITY

PHYSICS DEPARTMENT

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

DEFERRED TEST 1

COURSE: PH 110 **APRIL 2021**

ANSWER ALL QUESTIONS **TIME: TWO (2) HOURS**

QUESTION ONE

(a) Convert the following:

i. 100 mg into kg [2]

ii. 0.005 N into cgs system [2]

iii. 0.1 cm^2 into m^2 [2]

iv. 0.1 liters into cm^3 [2]

v. 2.5×10^{-10} m into μm [2]

(b) State two (2) advantages of using the method of Estimations and Order of Magnitude in calculations. [2]

(c) State two (2) disadvantages of using the method of Estimations and Order of Magnitude in calculations. [2]

(d) Given the vectors $\boldsymbol{A} = 5\hat{i} + 3\hat{j} + 2\hat{k}$ and $\boldsymbol{B} = -4\hat{i} + 4\hat{j} + 7k$. Find the angle between vectors $\boldsymbol{A}$ and $\boldsymbol{B}$ [5]

(e) A car initially at point X moves at constant velocity for 0.5 km eastward for 10 minutes to reach point Y and after point Y it suddenly changes to a constant velocity to move another 2 km eastward for 5 minutes to reach point Z.

(i) Calculate the average velocity in SI units for the scenario [3]

(ii) Calculate acceleration of the car from X to Z. [3]

QUESTION TWO

(a) Given that the three vectors $\boldsymbol{A} = 2\hat{i} + 3\hat{j} - 2\hat{k}$, $\boldsymbol{B} = -4\hat{i} + 3\hat{j} + 7\hat{k}$ and $\boldsymbol{C} = -\hat{i} + 4\hat{j} + 9\hat{k}$ act at one point in space. Find:

(i) The resultant vector [6]

(ii) The magnitude of the resultant vector [4]

(iii) The unit vector of the resultant [4]

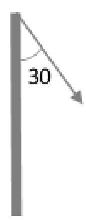
(iv) The direction of the resultant with respect to the x-axis [4]

(b) Given the vectors $\boldsymbol{A} = 2\hat{i} + 3\hat{j} - 2\hat{k}$, $\boldsymbol{B} = -4\hat{i} + 3\hat{j} + 7\hat{k}$ and $\boldsymbol{C} = -\hat{i} + 4\hat{j} + 9\hat{k}$.

Find the scalar triple product $\mathbf{A}.(\mathbf{B} \times \mathbf{C})$ [7]

QUESTION THREE

(a) A projectile is fired downwards with an initial velocity of 30 m/s at 30^o angle to the vertical (as shown) and hits the ground after 10 s. Use g = 9.82 m/s^2



Calculate:

(i) The final velocity on impact [4]

(ii) The height from which the projectile was fired [4]

(iii) The range of the projectile [3]

(iv) The x-component of the acceleration [2]

(b) A projectile is fired upward (vertically). It takes 30 seconds to come back to its starting point. Calculate:

(i) The maximum possible height reached [4]

(ii) The initial velocity [3]

(iii) The velocity halfway upwards [3]

(iv) Give one reason why in practice the time of ascent may be different from time of descent in projectile motions [2]

SOLUTION-QUESTION ONE

(a)

i. 1g = 1kg/1000 = 10^{-3} kg; 1mg = 1kg/1,000,000 = 10^{-6} kg; 100mg => 10^{-4} kg [2]

ii. 0.005 N = 0.005 kg.m/s^2 = 0.005 (1000)g(100)cm/s^2 = 100 g.cm/s^2 [2]

iii. 1cm = 10^{-2}m; 1cm^2 = $10^{-4}$$m^2$; 0.1$cm^2$ = $10^{-4}$$m^2$ x $10^{-1}$$cm^2$ = 10^{-5} m^2 [2]

iv. 1 L = 1000cm3; 0.1 L = 100 cm3 [2]

v. 2.5 x 10^{-10} m = 2.5 x 10^{-6} x10^{-4} m = 2.5 x 10^{-4} μm [2]

(b) - Estimates serve as a partial check if the exact calculations are correct.
- Calculations can be carried out where limited information is available
- Can be used where it is difficult or impossible to get an exact answer in a calculation [2]

(c) - It does not give precise answers

- Values close to each other cannot easily be estimated apart [2]

(d) Given the vectors ***A*** = $5\hat{i} + 3\hat{j} + 2\hat{k}$ and ***B*** = $-4\hat{i} + 4\hat{j} + 7k$. Find the angle between vectors ***A*** and ***B*** [5]

A.**B** = |**A**||**B**|cosθ; cosθ = **A**.**B**/|**A**||**B**|; θ = $\cos^{-1}$ (**A**.**B**/|**A**||**B**|)

But, **A**.**B** =5(-4) + 3(4) + 2(7) = -20 + 12 + 14 = **6**;

|**A**|= $\sqrt{5^2 + 3^2 + 2^2} = \sqrt{38}$

|**B**|= $\sqrt{(-4)^2 + 4^2 + 7^2} = \sqrt{81}$

Also $\sqrt{38}\text{x}\sqrt{81} = \mathbf{55.48}$

Hence θ = $\cos^{-1}$ (6/55.48); θ = $\cos^{-1}$ (0.108147); θ = $\cos^{-1}$ (0.108147) = 83.79^{o}

(e) A car initially at point X moves at constant velocity for 0.5 km eastward for 10 minutes to reach point Y and after point Y it suddenly changes to a constant velocity to move another 2 km eastward for 5 minutes to reach point Z.

(i) average velocity:

$$u = 0.5km/10\min = \frac{500m}{600s} = 0.833\ m/s$$

$$v = 2km/5\min = \frac{2000m}{300s} = 6.667\ m/s$$

Average velocity = (v+u)/2 = (6.667 + 0.833)/2 = 7.5 m/s [3]

(ii) acceleration from X to Z:

Acceleration = (v-u)/t; Acceleration = (6.667-0.833)/900= 6.48 x 10^{-3} m/s^2; [3]

SOLUTION - QUESTION TWO

(a) vectors $\boldsymbol{A} = 2\hat{\imath} + 3j - 2k$, $\boldsymbol{B} = -4i + 3j + 7k$ and $\boldsymbol{C} = -\hat{\imath} + 4j + 9k$

(i) The resultant vector **R**:

$\mathbf{R} = \mathbf{A} + \mathbf{B} + \mathbf{C} = (2-4-1)\,i + (3+3+4)\,j + (-2+7+9) = -3i + 10j + 14k$ [6]

(ii) magnitude of **R**: $R = \sqrt{(-3)^2 + 10^2 + 14^2} = \sqrt{305} = 17.46$ [4]

(iii) Unit vector of **R**: $\hat{R} = \frac{\boldsymbol{R}}{R} = \frac{-3i + 10j + 14k}{17.46}$ [4]

(iv) direction of **R**: $\text{Tan}(\theta) = 10/3 = 3.333$; $\theta = \text{Tan}^{-1}(3.333) = 73.3^{o}$ [4]

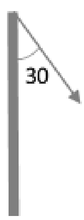
(b) Find the scalar triple product **A**.(**B** x **C**) :

$$(B \text{ x } C) = \begin{vmatrix} 2 & 3 & -2 \\ -4 & 3 & 7 \\ -1 & 4 & 9 \end{vmatrix} = 2(3\text{x}9 - 7\text{x}4) - 3(-4\text{x}9 + 1\text{x}7) - 2(-4\text{x}4 + 1\text{x}3)$$

$= -2 + 87 + 26 = 111$ [7]

SOLUTION - QUESTION THREE

(a) A projectile is fired downwards with an initial velocity of 30 m/s at 30^{o} angle to the vertical (as shown) and hits the ground after 10 s. Use $g = 9.82\ m/s^2$



(i) The final velocity on impact

$u_y = 30\cos(30) = 25.981 m/s$; $u_x = 30\sin(30) = 15 m/s$;

$v_y = u_y + a_y t = 25.981 + 9.82(10) = 124.181 m/s$

$v_x = u_x + a_x t = 15 + 0(10) = 15 m/s$

$v = \sqrt{{v_y}^2 + {v_x}^2} = \sqrt{124.181^2 + 15^2} = 125.08\ m/s$ [4]

(ii) The height from which the projectile was fired

${v_y}^2 = {u_y}^2 + 2a_y S_y$; $S_y = \frac{{v_y}^2 - {u_y}^2}{2a_y} = (124.181^2 - 25.981^2)/2(9.82)$

$= (15420.928 - 675.012)/19.64 = 14745.916/19.64 = 750.81\ m$ [4]

(iii) The range of the projectile

$S_x = \frac{(v_x+u_x)t}{2} = \frac{2v_xt}{2} = v_xt = 15(10) = 150\ m$ [3]

(iv) x-component of the acceleration = 0 m/s² due to constant velocity [2]

(b) A projectile is fired upward (vertically). It takes 30 seconds to come back to its starting point. Calculate:

(i) The maximum possible height reached:

Time taken to go up is 30/2= 15 s; $v_y = u_y + a_yt \Rightarrow 0 = u_y - 9.82(15)$

$u_y = 9.82(15) =$

$S_y = \frac{(v+u)t}{2} = \frac{(0+u)15}{2} = \frac{15u}{2} = \frac{9.82(15)(15)}{2} =$ [4]

(ii) The initial velocity

$u_y = 9.82(15) =$ [3]

(iii) The velocity halfway upwards

$v = \frac{u_y}{2} = \frac{9.82(15)}{2} =$ [3]

(iv) Give one reason why in practice the time of ascent may be different from time of descent in projectile motions: Air resistance [2]