MR - AMON CHILESHE

TEST ONE (1) PAPER

AND

Solutions 2017/2018 ACADEMIC YEAR

QUESTION ONE

(a) (i) For any equation to be valid, it must be *homogeneous*. Explain what is meant by a *homogeneous* equation. [2 marks]

(ii) The period of a spring executing simple harmonic motion is given by the equation:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where m is the mass and k is the spring constant given by $k = \frac{Force}{Displacement}$.

Show that the equation is homogeneous. [4 marks]

(b) What are the dimensions of a and b in the relation $F = at + bx$, where F is force, t is the time and x is the distance? [4 marks]

(c) The velocity v of water waves may depend on their wavelength λ, the density of water ρ and the acceleration due to gravity g. Establish dimensionally the relation between these quantities. [7 marks]

(d) If the velocity of light (3×10^8 m/s) is taken as the unit of velocity and a year is taken as the unit of time, what will be the unit of length? [3 marks]

(e) Density is defined as mass per unit volume. A neutron star has a density 2.8×10^{17} kg/m^3. Assume the star to be a perfect sphere. Find the radius of the neutron star whose mass is 4×10^{30} kg. [5 marks]

QUESTION TWO

(a) A particle undergoes three successive displacements in a plane as follows: 4.0 m southwest, 5.0 m east, 6.0 m in a direction 60° north of east. Choose the y–axis pointing north and the x–axis pointing east and find the

(i) magnitude and direction of the resultant displacement, and [7 marks]

(ii) displacement that would be required to bring the particle back to the starting point. [2 marks]

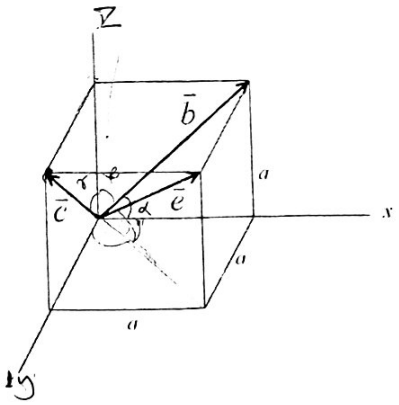
(b) When displacement $\vec{B}$ is added to displacement $\vec{A}$ the result is a displacement $\vec{C}$ that has components $C_x = -3.70\,cm$, $C_y = +2.25\,cm$ and $C_z = +4.60\,cm$. Displacements $\vec{A}$ and $\vec{B}$ are in the same direction, but the magnitude of $\vec{A}$ is only one–third that of $\vec{B}$. Find the components of $\vec{A}$. [4 marks]

(c) In the Figure below $\vec{b}$ and $\vec{c}$ are intersecting face diagonals of a cube of edge a. Find the

(i) components of the vector $\vec{d}$, where $\vec{d} = \vec{b} \times \vec{c}$. [4 marks]

(ii) between $\vec{b}$ and $\vec{c}$. [4 marks]
the angle θ,

(iii) direction cosines of the body diagonal $\vec{e}$. [4 marks]



QUESTION THREE

(a) A ballast bag is dropped from a balloon that is 300 m above the ground and rising at 13 m/s. For the bag, find

(i) the maximum height reached, [2 marks]

(ii) its position and velocity 5 s after it is released, and [2 marks]

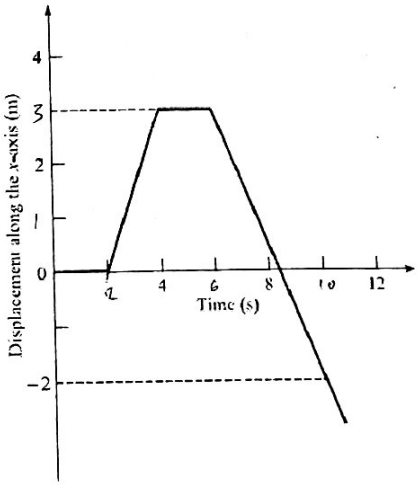
(iii) the time at which it hits the ground. [4 marks]

(b) A ball is thrown from the top of one building towards a very tall building 50 m away. The initial velocity of the ball is 20 m/s, 40° above the horizontal.

(i) At what height, relative to the original level, will the ball strike the opposite wall? [4 marks]

(ii) Is the height in part (i) above or below the original level? Explain. [2 marks]

(c) The graph in the Figure below shows an object's one–dimensional motion along the x-axis. Describe its motion. [3 marks]



(d) A motorcycle policeman hidden at an intersection observes a car that ignores a stop sign, crosses the intersection, and continues on at constant speed. The policeman starts off in pursuit 2.0 s after the car has passed the stop sign, accelerates at 6.2 m/s^2 until his speed is 110 km/h, and then continues at this speed

until he catches the car. At that instant, the car is 1.4 km from the intersection. How fast was the car traveling? [8 marks]

QUESTION FOUR

(a) Action and reaction forces are equal and opposite, yet they do not cancel each otherresulting in zero net force. Why? [2 marks]

(b) A mini bus is moving at the speed of 72 km/h on a horizontal straight rough road. Just before reaching the CBU station, the engine suddenly switches off and the bus skids to a stop through a distance of 50 m. Calculate the coefficient of kinetic frictionbetween the road and the bus's tyres. [5 marks]

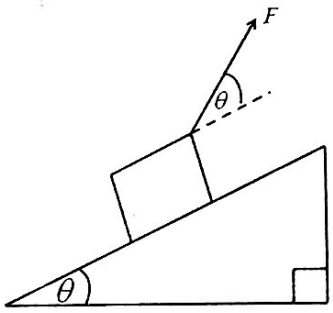
(c) An object of mass 10 g is moving along the x-axis. Its position as a function of time is given by

$$x = (4t^3 + 2t)m$$

Find the magnitude of the force acting on the object at $t = 2$ s. [4 marks]

(d) A man gardening pushes a lawnmower at a constant speed. To do this requires a force of 80 N directed along the handle, which is at an angle of 30^0 below the horizontal. The coefficient of kinetic friction between the lawnmower and the surface is 0.25. Find the mass of the lawnmower. [5marks]

(e) A block of mass m on a rough inclined surface is acted upon by a force F at an angle θ with the incline as shown below. The surface is inclined at an angle θ and the coefficient of kinetic friction between the block and the surface is μ_k



(i) Draw the free body diagram of the block. [2 marks]

(ii) Show that the acceleration of the block is

$$a = \frac{F(\cos\theta + \mu_k \sin\theta) - mg(\sin\theta + \mu_k \cos\theta)}{m}$$ [7 marks]

********** *Good Luck* **********