ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27

M.Sc. PHYSICS - I SEMESTER

SEMESTER EXAMINATION- JANUARY 2021

PHBC 7120 – MATHEMATICAL PRELIMINARIES AND NEWTONIAN MECHANICS

Time-1 hrs.   **Maximum Marks-35**

This question paper has 3 printed pages and 2 parts

PART A
Answer any **FOUR** OR **THREE** full questions.

1. Consider the following equation $2x^2 + 5x = 2$
   (a) Find the roots of this equation
   (b) Plot a rough sketch of this equation

   (2,3)

2. Consider the vectors $|V\rangle = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$ and $|U\rangle = \begin{pmatrix} 2 \\ 5 \\ 4 \end{pmatrix}$

   (a) What is the inner product of these vectors?
   (b) What is the length of the projection of $|V\rangle$ on $|U\rangle$
   (c) What is the vector of projection from the previous case

   (1,2,2)

3. Consider a ball rolling down a slope angled at θ . If the perpendicular of the inclined plane is along the 'y' axis and the base is along the 'x' axis, what matrix can we use in order to orient the axis along the Normal force and the rolling force? If θ is equal to 30° how will the matrix look?
   [**HINT** : First draw the free body diagram and then notice the symmetry, 'mg' is only a scaling factor] [**HINT** : The second question is a hint to the first one].
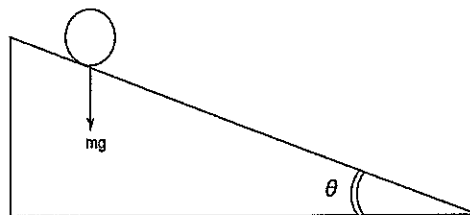
4. Consider that I am throwing a party which only 2 people attend (Sad life). But as we like to eat a lot, we decide to buy food with the deal that I pay for the starters, my friend Sheila pays for the cola and my other friend John pays for the biriyani. Then if we order

3 Biriyanis	2 Starters	3 Cokes	For 750 rupees
2 Biriyanis	3 Starters	4 Cokes	For 600 rupees
1 Biriyani	3 Starters	2 Cokes	For 560 rupees

over 3 sessions. How much should each of us pay. (Read the question very carefully)

5. Consider the following function ($3x^2 - 5x = 0$). Use Newton-Raphson, given by the iterative equation $x_{i+1} = x_i - \dfrac{f(x_i)}{f'(x_i)}$ to arrive at the marked root and verify the solution analytically . [Show the steps you take]

$$3x^2 - 5x = 0$$
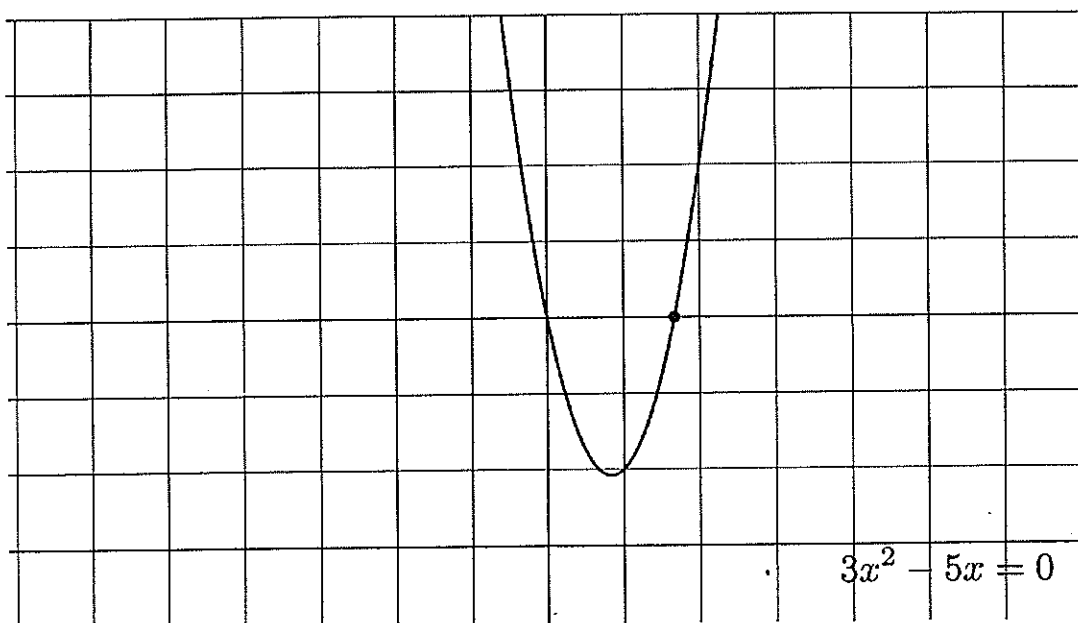
PART B
Answer any THREE full questions if you answered FOUR full questions in PART A; else answer any FOUR full questions.

1. Write down the equations of kinematics for a particle moving with an acceleration a along the x axis as a function of time t . Assume the initial velocity of the particle to be u .
   (a) Where on the x axis will the minimum lie?
   (b) Graphically (and neatly) illustrate this by drawing on your answer sheet (since no numbers have been given, your graph is not expected to be to scale).
   (c) Mention in words (no graph needed) as to how the position of the minimum will depend on the sign of u and a . **(2+1.5+1.5)**

2. A particle of mass m is thrown at an angle α with respect to the x axis with a velocity

u . The object will undergo projectile motion. Derive the equation of trajectory of the particle.

3.
   (a) State Newton's Second Law.
   (b) Explain Newton's Second Law using the example of an inelastic collision between a tennis ball and a wall.
   (c) A block of mass 0.5 kg is dragged along a frictionless floor by a string. The string is held at an angle of $30°$ and the block has an acceleration of 0.5 m s^{-2} . What is the force exerted by the string on the block?   **(1+2+2)**

4.
   (a) A particle is executing a uniform circular motion with a tangential velocity of v along a circle of radius r . If the radius of the circle is doubled, what would its new tangential velocity be in terms of v ?
   (b) A stone tied to the end of a string is set into uniform circular motion in a horizontal plane (you can ignore the effect of gravity in this problem). The stone has a linear tangential velocity of 10 m s^{-1} and the string is 20 cm long. Find the angular velocity of the stone.   **(3+2)**

5. A block of mass m is acted upon by variable force that depends on position given by the expression: $\vec{F}(x) = k x \hat{i}$ where k is a constant and $\hat{i}$ is a unit vector along the x (horizontal) direction. What is the work done on the block as it is moved from a position of $x = a$ to $x = b$?

PHBCH 20-A-20