University of California, San Diego
Department of Mathematics

Instructions:

1. **Write your *Name*, *PID*, and *Section* on the front of your Blue Book.**
2. **Write the *Version* of your exam on the front of your Blue Book.**
3. **No calculators or other electronic devices are allowed during this exam.**
4. **You may use one page of notes, but no books or other assistance during this exam.**
5. **Read each question carefully, and answer each question completely.**
6. **Write your solutions clearly in your Blue Book**
   (a) **Carefully indicate the number and letter of each question.**
   (b) **Present your answers in the same order they appear in the exam.**
   (c) **Start each question on a new page.**
7. **Show all of your work; no credit will be given for unsupported answers.**

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1. Let $\boldsymbol{a} = 2\boldsymbol{i} + \boldsymbol{j} - \boldsymbol{k}$ and $\boldsymbol{b} = \boldsymbol{i} + \boldsymbol{k}$. [15]
   (a) Determine the angle between $\boldsymbol{a}$ and $\boldsymbol{b}$.
   (b) Find a unit vector orthogonal to both $\boldsymbol{a}$ and $\boldsymbol{b}$.
   (c) Find parametric equations for the line in $\mathbb{R}^3$ that passes through the point $(3, -5, 6)$ and is perpendicular to the plane containing $\boldsymbol{a}$ and $\boldsymbol{b}$.

2. Find the equation of the plane containing the triangle with vertices $P = (1, 0, 2)$, $Q = (3, 1, -2)$, and $R = (1, -1, 3)$. [5]

3. The position of a particle in space at time t is given by the vector function: [15]
$$\boldsymbol{r}(t) = \sin(t^2)\,\boldsymbol{i} + \cos(t^2)\,\boldsymbol{j} + 3t^2\,\boldsymbol{k}, \qquad t \geq 4.$$
   (a) Find the velocity and acceleration at time t.
   (b) Find the ***initial*** speed at time $t = 4$.

4. A curve is described by the parametric equations [10]
$$x = \ln t, \quad y = 2t, \quad z = t^2, \qquad t \geq 1.$$
   (a) Find the parametric equations of the tangent line at the point $(0, 2, 1)$; that is, when $t = 1$.
   (b) Find the length of the curve for $1 \leq t \leq e$.

5. A constant force with magnitude 20 N acts directly upward from the xy-plane on an object with mass 4 kg. The object starts at the origin with initial velocity $\boldsymbol{v}(0) = \boldsymbol{i} + \boldsymbol{j}$. Find its position function at time t. [Recall Newton's Second Law of Motion: $\boldsymbol{F} = m\boldsymbol{a}$.] [5]

(This exam is worth 50 points.)