Work alone and use no books, notes, or calculators. Show your work with your answers on $8.5^{\circ} \times 11^{\circ}$ paper and staple the pages to the exam when you turn them in.

Problem 1 (10%) Find the constant k such that the vectors $\mathbf{A} = \langle -2, 1, 3 \rangle$ and $\mathbf{B} = \langle -1, 4, k \rangle$ are perpendicular. **Problem 2** (10%) Find the angle θ ($0 \le \theta \le \pi$) between the vectors $\mathbf{C} = \langle 1, 1, 1 \rangle$ and $\mathbf{D} = \langle 1, 2, -2 \rangle$.

Problem 3 (10%) What is the vertex R opposite P in the parallelogram PQRS if P = (1, 1, 1), Q = (3, 3, 3) and S = (-1, 4, 2)?

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Problem 4 (10%) Give parametric equations of the line through (3, 1, 2) and perpendicular to the plane x - y + 2z = 5.

Problem 5 (10%) Give parametric equations of the line through the points P = (1, 4, 2) and Q = (2, 3, 0).

Problem 6 (10%) Give an equation of the plane through the points O(0,0,0), P(2,0,3), and Q(2,-1,1).

Problem 7 (10%) The vertices of a tetrahedron are O = (0, 0, 0), P = (1, 2, 3), Q = (0, 1, 5) and R = (4, 0, 1). What is its volume?

Problem 8 (10%) Draw the curve in an xy-plane with the parametric equations C: x = x(t), $y = y(t), 0 \le t \le 4$, where the graphs of x = x(t) and y = y(t) are in Figures 1 and 2. Show the curve's orientation.



Problem 9 An object is at $x = t - t^2$ (miles), $y = t^2 + t$ (miles) in an *xy*-plane at time *t* (hours) for $-2.1 \le t \le 2.1$. Its path is in Figure 3.

(a) (10%) Show that the object's speed is $\sqrt{2+8t^2}$ miles per hour at time t.

(b) (10%) Find the object's velocity vector at the point where its speed is a minimum and draw it with the curve. Use the scales on the coordinate axes to measure the components of the vector.



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