1. Determine, for vectors $\mathbf{u} = \mathbf{i} + 2\mathbf{j} - \mathbf{k}$, $\mathbf{v} = -\mathbf{i} + \mathbf{j} + \mathbf{k}$, $\mathbf{w} = \mathbf{i} + \mathbf{k}$
   (a) (10 points) A unit vector in the direction $\mathbf{u} + 2\mathbf{v} - 3\mathbf{w}$
   (b) (10 points) The triple product $\mathbf{u} \cdot (\mathbf{v} \times \mathbf{w})$

2. Given the points $P(1, 1, 1)$, $Q(2, 1, 3)$ and $R(3, -1, 1)$ in space,
   (a) (7 points) Find the cosine of the angle between $\overrightarrow{PQ}$ and $\overrightarrow{PR}$.
   (b) (7 points) Find the area of the triangle $\triangle PQR$ using a cross product.
   (c) (6 points) Find an equation for the plane through the points P, Q, and R.

3. (a) (10 points) Find the point where the line through $P(2, 2, 3)$ and $Q(0, -2, -1)$ intersects the plane $2x + y + 2z = 4$.
   (b) (10 points) Find the distance from the point $P(2, 2, 3)$ to the plane $2x + y + 2z = 4$.

4. The position vector of a particle moving through space is

$$\mathbf{r}(t) = \cos(3t)\,\mathbf{i} + (\tan^{-1} t)\,\mathbf{j} + t^2\,\mathbf{k}.$$

   (a) (10 points) Find the particle's velocity and acceleration vectors.
   (b) (5 points) Find the angle between the velocity and acceleration vectors at $t = 0$.
   (c) (5 points) Find the parametric equations of the tangent line to the curve described by the particle at $t = 0$.

5. (a) (10 points) Find the position vector $\mathbf{r}(t)$ for a particle moving in the space with

$$\frac{d\mathbf{r}}{dt} = 2te^{t^2}\ \mathbf{i} + \sec t \tan t\ \mathbf{j} + \frac{1}{t+1}\ \mathbf{k}, \quad \mathbf{r}(0) = \mathbf{i} + \mathbf{k}.$$

   (b) (10 points) Find the length of the indicated portion of the curve.

$$\mathbf{r}(t) = e^t \cos t\ \mathbf{i} + e^t \sin t\ \mathbf{j} - \sqrt{2}e^t\ \mathbf{k}, \quad 0 \le t \le \ln 2.$$