1. (20 points) Let $\overrightarrow{P} = (1, 0, -1)$, $\overrightarrow{Q} = (1, 1, 1)$ and $\overrightarrow{R} = (1, -2, 1)$.

   1. Find the cosine of the angle between $\overrightarrow{P}$ and $\overrightarrow{Q}$.

   2. Find the equation of the plane containing $\overrightarrow{P}$, $\overrightarrow{Q}$ and $\overrightarrow{R}$.

   3. Compute the following quantities if possible; if not possible, state why not:
      - ◇ (i) $(\overrightarrow{P} \times \overrightarrow{Q}) \times \overrightarrow{R}$;
      - ◇ (ii) $(\overrightarrow{P} \times \overrightarrow{Q}) \cdot \overrightarrow{R}$;
      - ◇ (iii) $(\overrightarrow{P} \cdot \overrightarrow{Q}) \times \overrightarrow{R}$.

   4. Let $f(x, y, z) = \sin(xyz)$. Find the directional derivative of $f(x, y, z)$ at the point $\overrightarrow{P}$ in the direction $\overrightarrow{Q}$.

   5. Let $f(u, v) = u^2 + v^2$, $g(x, y, z) = (\sin(xy) + z, e^x + yz)$ and set $h(x, y, z) = f(g(x, y, z)$. Using the Chain Rule, compute $\frac{\partial h}{\partial x}$, $\frac{\partial h}{\partial y}$ and $\frac{\partial h}{\partial z}$ at the point $(0, 0, 0)$.