1. If \( F \) is a function of \( t \), find the derivative of

\[
F \cdot \frac{dF}{dt} \times \frac{d^2F}{dt^2}
\]

2. Let \( \mathbf{r} = xi + yj + zk \) represents the position vector from a fixed origin \( O \) to a point \( P \), and suppose that the \( xyz \) axis system is rotating about a fixed vector \( \omega \) through \( O \), with angular velocity of constant magnitude \( \omega \).

   (a) By calculating \( \frac{dr}{dt} \) and noticing that \( \frac{di}{dt} = \omega \times i \), and so forth, obtain the velocity vector in the form

\[
\mathbf{v} = \mathbf{v}_O + \omega \times \mathbf{r}
\]

where the vector

\[
\mathbf{v}_O = \frac{dx}{dt} \mathbf{i} + \frac{dy}{dt} \mathbf{j} + \frac{dz}{dt} \mathbf{k}
\]

is the velocity vector which would be obtained if the axes were fixed.

   (b) Obtain the acceleration vector in the form

\[
\mathbf{a} = \mathbf{a}_O + 2\omega \times \mathbf{v}_O + \omega \times (\omega \times \mathbf{r}),
\]

where \( \mathbf{v}_O \) is defined in part (a), and where

\[
\mathbf{a}_O = \frac{d^2x}{dt^2} \mathbf{i} + \frac{d^2y}{dt^2} \mathbf{j} + \frac{d^2z}{dt^2} \mathbf{k}
\]

3. Determine the unit vector normal to the surface \( x^3 - xyz + z^3 = 1 \) at the point \((1,1,1)\).

4. Show that \( \nabla \cdot (x\mathbf{v}) = x\nabla \cdot \mathbf{v} + \mathbf{i} \cdot \mathbf{v} \) and \( \nabla \times (x\mathbf{v}) = x\nabla \times \mathbf{v} + \mathbf{i} \times \mathbf{v} \)