1) Let $C$ be the curve of intersection of the surfaces $y = x^2$ and $z = \frac{2}{3}x^3$. A particle moves along $C$ with constant speed such that $\frac{dx}{dt} > 0$. The particle is at $(0, 0, 0)$ at time $t = 0$ and is at $(3, 9, 18)$ at time $t = \frac{7}{2}$.
   a) Find the length of the part of $C$ between $(0, 0, 0)$ and $(3, 9, 18)$.
   b) Find the constant speed of the particle.
   c) Find the velocity of the particle when it is at $(1, 1, \frac{2}{3})$.
   d) Find the acceleration of the particle when it is at $(1, 1, \frac{2}{3})$.

2) Let $\vec{F} = (y^2e^{3z} + Axy^3) \hat{i} + (2xye^{3z} + 3x^2y^2) \hat{j} + Bxy^2e^{3z} \hat{k}$.
   a) For what values of the constants $A$ and $B$ is the vector field $\vec{F}$ conservative on $\mathbb{R}^3$?
   b) If $A$ and $B$ have the values found in (a), find a scalar potential function for $\vec{F}$.
   c) Let $C$ be the curve $\vec{r} = e^{2t} \hat{i} - e^{-t} \hat{j} + \ln(1 + t) \hat{k}$ from $(1, 1, 0)$ to $(e^2, 1, \ln 2)$. Evaluate
      $\int_C (y^2e^{3z} + xy^3) \, dx + (2xye^{3z} + 3x^2y^2) \, dy + 3xy^2e^{3z} \, dz$

3) Let $S$ be the part of the surface $z = xy$ that lies above the square $0 \leq x \leq 1$, $0 \leq y \leq 1$ in the $xy$–plane.
   a) Find $\iint_S \frac{x^2y}{\sqrt{1+x^2+y^2}} \, dS$.
   b) Find the flux of $\vec{F} = x^2 \hat{i} + y \hat{j} + \hat{k}$ upward through $S$.

4) Evaluate $I = \oint_C \left( 2y^2 - x^4 \right) \, dx + (xy^4 + x^3y^2) \, dy$ counterclockwise around the boundary of the half–disk $0 \leq y \leq \sqrt{4 - x^2}$.

5) Find the flux of $\vec{F} = xy^2 \hat{i} + x^2y \hat{j} + \hat{k}$ outward through the hemispherical surface $x^2 + y^2 + z^2 = 4$, $z \geq 0$. (Hint: the flux can be calculated directly, but it is rather easier to calculate it using the Divergence Theorem.)

6) Let $C$ be a circle of radius $R$ lying in the plane $x + y + z = 3$. Use Stokes’ Theorem to calculate the value of
   $\int_C \vec{F} \cdot d\vec{r}$
   where $\vec{F} = z^2 \hat{i} + x^2 \hat{j} + y^2 \hat{k}$. (You may use either orientation of the circle.)