Please remember that each final exam is different, and the style and emphasis of the questions will vary from semester to semester.

[12] 1. A particle moves along the curve $\mathbf{r}(t) = \langle 0,\ 10t,\ 25t - 5t^2 \rangle$. Find its velocity $\mathbf{v}(t)$, speed $v(t)$, acceleration $\mathbf{a}(t)$ and curvature $\kappa(t)$.

[6] 2. Find a unit normal vector to the surface $xyz = 16$ at the point $P(-2, 2, -4)$ and determine the equation of the tangent plane at P.

[6] 3. Consider the function $f(x, y, z) = x^2 - 2y^2 + 3z^2$ at the point $P(2, 3, -1)$. Find the maximum rate of change of f at P and the unit vector that points in the direction of maximum increase.

[8] 4. Consider the surface S described parametrically by $\mathbf{R}(u, v) = \langle 3u\cos(v),\ 3u\sin(v),\ 4u \rangle$ for $0 \le u \le 2$ and $0 \le v \le 2\pi$. Find the surface area of S.

[12] 5. Let E be the solid which lies above the xy-plane and between the spheres of radius 1 and 2 both centred at the origin. Evaluate $\displaystyle\iiint_E z(x^2 + y^2 + z^2)\, dV$.

[12] 6. Let $\mathbf{F}(x, y, z) = \langle x^2,\ \cos(y)\sin(z),\ \sin(y)\cos(z) \rangle$ and C be the curve defined by the function $\mathbf{r}(t) = \langle t^2 + 1,\ e^t,\ e^{2t} \rangle$ for $0 \le t \le 2$. Use the Fundamental Theorem of Line Integrals to evaluate $\displaystyle\int_C \mathbf{F} \cdot d\mathbf{r}$.

[6] 7. Consider $\mathbf{F}(x, y, z) = \left\langle xz - y^2,\ 2yz,\ 3z \right\rangle$. Calculate curl($\mathbf{F}$) and div($\mathbf{F}$).

[8] 8. Show that div(curl($\mathbf{F}$)) = 0 for any vector field $\mathbf{F}$.

[18] 9. Verify Stokes' Theorem for the vector field $\mathbf{F} = \langle 2xy,\ x,\ y + z \rangle$ and the surface S consisting of the portion of the hyperbolic paraboloid $z = 1 - x^2 - y^2$ lying above the unit circle $x^2 + y^2 = 1$.

[12] 10. Let E be the tetrahedron bounded by the planes $x = 0$, $y = 0$, $z = 0$ and $x + y + z = 1$. For $\mathbf{F} = \langle 2x,\ 3xz,\ -z \rangle$ use the Divergence Theorem to evaluate $\displaystyle\iint_{\partial E} \mathbf{F} \cdot d\mathbf{S}$.