1. (22 points) Let $v = 4i + 2j - k$, $w = 3i - 2j - 3k$, and $P$ be the point $(-1, 5, 2)$.
   a. Compute $2v - w$.
   b. If $w = \overrightarrow{PQ}$, compute the coordinates of the point $Q$.
   c. Compute a unit vector in the opposite direction to $v$.
   d. Compute the cosine of the angle between $v$ and $w$.
   e. Compute $\text{pr}_w v$, the vector projection of $v$ along $w$.
   f. Give parametric equations for the line that passes through the point $P$ and that has direction given by $v$.
   g. Give an equation for the plane whose normal vector is perpendicular to both $v$ and $w$, and which contains the point $P$. 
2. (10 points) A line $\ell_1$ passes through the points $(2, 0, 5)$ and $(1, 3, 1)$. A line $\ell_2$ has parametric equations $x = 1 + t$, $y = 5 + t$, $z = -4 - 6t$.
   a. Find parametric equations for $\ell_1$.
   b. Find the point of intersection of the two lines. (Suggestion: use symmetric equations for one of the lines.)

3. (6 points) Find equations for a line $L$ that is parallel to the plane $2x + 4y - z = 5$, but does not lie in this plane.

4. (8 points) Compute $f_r$ and $f_s$ for $f(r, s) = r^3 \ln(r^6 + s^2)$. 
5. (14 points) A particle moves so that \( \mathbf{r}(t) = (5t, 3\cos t, 3\sin t) \).
   a. Compute the velocity, the speed, and the distance traveled from \( t = 0 \) to \( t = 2\pi \).
   b. Describe the path of the motion from \( t = 0 \) to \( t = 2\pi \).

6. (8 points) Sketch the surface \( x^2 + y^2 - 4z^2 = 16 \). Show at least three different traces.

7. (4 points) Sketch the surface \( 4x^2 + 8z = 0 \).
8. (10 points) The density $\rho$ (in g/cm$^3$) of carbon dioxide gas is directly proportional to the pressure $P$ (in atmospheres) and inversely proportional to the temperature $T$ (in degrees Kelvin).
   a. Write an equation for $\rho$ in terms of $P$ and $T$, and compute the proportionality constant if $\rho = .002$ at $T = 273^\circ$ K and $P = 1.018$.

   b. Compute $\frac{\partial \rho}{\partial P}$ and $\frac{\partial \rho}{\partial T}$.

9. (10 points) The table of values below gives heat index $I$ in terms of sample values of temperature $T$ and relative humidity $h$.

   a. Is $I$ a linear function of $h$ and $T$? If yes, produce the formula; if no, explain why not.

   b. Estimate $I$ if $T = 88$ and $h = 40$.

   c. Estimate $I$ if $T = 88$ and $h = 44$. 
10. (8 points) Give the number of the contour diagram that corresponds to each of the labeled 3D graphs.

A ___________ B ___________ C ___________ D ___________