

Show your work for full credit. Calculators are allowed.

1. (22 points) Let $\mathbf{v} = 4\mathbf{i} + 2\mathbf{j} - \mathbf{k}$, $\mathbf{w} = 3\mathbf{i} - 2\mathbf{j} - 3\mathbf{k}$, and P be the point $(-1, 5, 2)$.
 - a. Compute $2\mathbf{v} - \mathbf{w}$.

 - b. If $\mathbf{w} = \overrightarrow{PQ}$, compute the coordinates of the point Q .

 - c. Compute a unit vector in the opposite direction to \mathbf{v} .

 - d. Compute the cosine of the angle between \mathbf{v} and \mathbf{w} .

 - e. Compute $\text{pr}_{\mathbf{w}}\mathbf{v}$, the vector projection of \mathbf{v} along \mathbf{w} .

 - f. Give parametric equations for the line that passes through the point P and that has direction given by \mathbf{v} .

 - g. Give an equation for the plane whose normal vector is perpendicular to both \mathbf{v} and \mathbf{w} , and which contains the point P .

2. (10 points) A line ℓ_1 passes through the points $(2, 0, 5)$ and $(1, 3, 1)$. A line ℓ_2 has parametric equations $x = 1 + t$, $y = 5 + t$, $z = -4 - 6t$.
- Find parametric equations for ℓ_1 .
 - 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 $f(r, s) = r^3 \ln(r^6 + s^2)$.

8. (10 points) The density ρ (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).
- Write an equation for ρ in terms of P and T , and compute the proportionality constant if $\rho = .002$ at $T = 273^\circ \text{K}$ and $P = 1.018$.
 - 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 .
- Is I a linear function of h and T ? If yes, produce the formula; if no, explain why not.
 - Estimate I if $T = 88$ and $h = 40$.
 - 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 _____