

1. (24 pts) Consider the points  $P(0, 9, 2)$  and  $Q(-2, 10, 5)$ .
- Find an equation for the set of points equidistant from point  $P$  and the plane  $z = 7$ . You may leave your answer unsimplified.
  - Let  $\mathbf{v}$  equal the vector  $\overrightarrow{PQ}$  and let  $\mathbf{w} = \overrightarrow{PR} = \langle 4, 5, 1 \rangle$ , where  $R$  is another point in space.
    - Find the distance between points  $Q$  and  $R$ .
    - Find the projection of  $\mathbf{w}$  onto  $\mathbf{v}$ .
    - Find a unit vector orthogonal to  $\mathbf{v}$  and  $\mathbf{w}$ .

2. (28 pts) Let  $L_1$  and  $L_2$  be the lines whose symmetric equations are

$$L_1 : x = \frac{y+4}{2} = \frac{z-1}{2} \quad L_2 : \frac{x}{2} = \frac{y+4}{3} = \frac{z-1}{6}.$$

- Write parametric equations for  $L_1$  and  $L_2$ .
  - Find the point where  $L_1$  intersects the  $xz$  plane.
  - Find the angle formed by  $L_1$  and  $L_2$ .
  - Find an equation for the plane that contains  $L_1$  and  $L_2$ .
3. (24 pts) Consider the surface  $x^2 + y^2 - z^2 - 2x + 6y - 6 = 0$ .
- Write the equation in standard form.
  - Identify the surface.
  - Sketch the  $z = 3$  trace.
  - Suppose the surface is intersected with the surface  $z - y = 3$ . Find vector equation(s) for the curve(s) of intersection.
4. (24 pts) A bug is traveling along a path. Its position at time  $t$  seconds is  $\mathbf{r}(t) = t\mathbf{i} + 2t\mathbf{j} + \frac{2}{3}t^{3/2}\mathbf{k}$ , measured in centimeters.
- How far does the bug travel from  $t = 0$  to 4 seconds? You may leave the final answer unsimplified.
  - Consider the plane  $4x - y - z = 13$ . Is the vector tangent to the path at  $t = 4$  parallel to the plane, orthogonal to the plane, or neither?
  - At  $t = 4$ , the bug leaves the path and travels in a straight line in the direction of the tangent vector. Find a vector function representation  $\mathbf{s}(t)$  for this straight path.