   Instructions: Show your work in the spaces provided below for full credit. Use the reverse side for additional space, *but clearly so indicate.* You must clearly identify answers and show supporting work to receive any credit. Exact answers (e.g., π) are preferred to inexact (e.g., 3.14). Point values of problems are given in parentheses. Notes or text in *any* form not allowed. Calculator is required.

(32) **1.** Given the vectors $\mathbf{a} = \mathbf{i} + 4\mathbf{j} + 5\mathbf{k}$, $\mathbf{b} = -2\mathbf{i} + \mathbf{j} + 2\mathbf{k}$ and $\mathbf{c} = \mathbf{j} + \mathbf{k}$, find the following:

(a) A unit vector in the direction of $\mathbf{a}$.

(b) The angle between $\mathbf{a}$ and $\mathbf{b}$.

(c) The area of a parallelogram with adjacent sides formed by representatives of $\mathbf{a}$ and $\mathbf{c}$.

(d) $\text{proj}_{\mathbf{b}}\mathbf{a}$ and $\text{comp}_{\mathbf{b}}\mathbf{a}$.
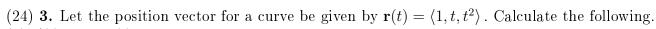
(36) **2.** You are given two straight line paths

$$P_1 : \begin{cases} x &=& 3 \\ y &=& 6 - 2t \\ z &=& 3t + 1 \end{cases} \quad \text{and } P_2 : \begin{cases} x &=& 1 + 2s \\ y &=& 3 + s \\ z &=& 2 + 2s \end{cases}$$

(a) Show that these lines intersect.

(b) Find a vector orthogonal to both lines.

(c) Find the equation of a plane containing both lines.

(d) Find the distance from this plane to the origin.

(24) **3.** Let the position vector for a curve be given by $\mathbf{r}(t) = \langle 1, t, t^2 \rangle$. Calculate the following.

(a) $\mathbf{r}'(t)$ and $\int \mathbf{r}(t)\, dt$.

(b) Values of t at which $\mathbf{r}(t) \perp \mathbf{r}'(t)$.

(c) Arc length of the portion of the curve from $t = 0$ to $t = 2$ (you may use your calculator).

(8) **4.** Identify this surface and roughly sketch its traces and graph: $\dfrac{x^2}{4} + \dfrac{y^2}{4} + \dfrac{z^2}{9} = 1$.