Question 1 [5 points] Equation of the plane given that the vector
\[ \vec{v} = \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} \]
is a normal to it at point \((1, 1, 1)\) is

- \( \text{A} \) \( x + 2y + z - 4 = 0 \)
- \( \text{B} \) \( 2x + y + z - 4 = 0 \)
- \( \text{C} \) \( x + y + 2z - 4 = 0 \)
- \( \text{D} \) \( x + y + z - 3 = 0 \)
- \( \text{F} \) \( 2x + y + 2z - 5 = 0 \)
Question 4  [12 points] Consider the surface of the sphere given by the equation $(x - 3)^2 + (y - 4)^2 + z^2 = 25$. You shoot a ray from the point $(8, 4, 0)$ along the vector

$$\vec{v} = \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}.$$  

The *outward* unit vectors normal to the surface of the sphere at the intersection points of the ray and the sphere are

- **A** $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 1/\sqrt{2} \\ 0 \\ 1/\sqrt{2} \end{pmatrix}$
- **B** $\begin{pmatrix} 2/3 \\ 1/3 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$
- **C** $\begin{pmatrix} 1/\sqrt{2} \\ 0 \\ 1/\sqrt{2} \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1/\sqrt{2} \\ 1/\sqrt{2} \end{pmatrix}$
- **D** $\begin{pmatrix} 1/3 \\ 2/3 \\ 2/3 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 2/3 \\ 1/\sqrt{2} \end{pmatrix}$
- **E** $\begin{pmatrix} 2/3 \\ 1/3 \\ 2/3 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1/3 \\ 1 \end{pmatrix}$
- **F** $\begin{pmatrix} 0 \\ 1/\sqrt{2} \\ 1/\sqrt{2} \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix}$

Question 5  [4 points] What are the lower and upper bounds of the response time for a game running at a constant 50 frames per second?

- **A** Lower bound is 10ms, upper bound is 20ms.
- **B** Lower bound is 20ms, upper bound is 40ms.
- **C** Lower bound is 0 ms, upper bound is 40ms.
- **D** Lower bound is 10ms, upper bound is 40ms.
- **E** Lower bound is 0ms, upper bound is 20ms.

Question 6  [3 points] There are two vectors

$$\vec{v} = \begin{pmatrix} 2 \\ 1 \\ 1 \end{pmatrix} \quad \text{and} \quad \vec{w} = \begin{pmatrix} 1 \\ 0 \\ -2 \end{pmatrix}.$$  

The quantity $u = \vec{v} \cdot (\vec{v} \times \vec{w})$ equals

- **A** -1
- **B** 0
- **C** -2
- **D** 3
- **E** 2
- **F** 1
Question 10  [19 points]  As shown in the picture below, a bar AB is placed in three dimensions, with the locations of $A = (8, 0, 3)$ and $B = (20, 0, 12)$. The bar is being viewed by the eye located at $E = (0, 0, -4)$, and the view is being projected on the two-dimensional screen, which is simply the $xy$-plane. On the screen, $A'$ is the projection of $A$, $P'$ is the projection of $P$ and so on. The distance $AP$ is given by $l$ and the distance $A'P'$ is given by $t$. The quantity $t$ relates to $l$ as

- **A** $t = \frac{16l}{7(3l + 35)}$
- **B** $t = \frac{9l}{l + 14}$
- **C** $t = \frac{2l}{2l + 15}$
- **D** $t = \frac{15l}{3l + 21}$
- **E** $t = \frac{8l}{l + 3}$
- **F** $t = \frac{15l}{2l + 11}$
- **G** $t = \frac{5l}{3l + 4}$
- **H** $t = \frac{8l}{l + 17}$

Question 11  [8 points]  The unit vectors perpendicular to the triangular plane formed by $A = (4, -1, -3)$, $B = (5, -5, -2)$ and $C = (3, -3, -3)$ is

- **A** $\pm \begin{pmatrix} -3/13 \\ 4/13 \\ 12/13 \end{pmatrix}$
- **B** $\pm \frac{1}{\sqrt{11}} \begin{pmatrix} 2 \\ -1 \\ -6 \end{pmatrix}$
- **C** $\pm \begin{pmatrix} -2/3 \\ 1/3 \\ 2/3 \end{pmatrix}$
- **D** $\pm \begin{pmatrix} 3/13 \\ -4/13 \\ 12/13 \end{pmatrix}$
- **E** $\pm \begin{pmatrix} 3/13 \\ 4/13 \\ 12/13 \end{pmatrix}$
- **F** $\pm \begin{pmatrix} 2/3 \\ -1/3 \\ 2/3 \end{pmatrix}$
**Question 12 [15 points]** As shown in the picture below, a bar AB is placed on the two-dimensional plane, with the locations of A = (2, 4) and B = (5, 8). The bar is being viewed by the eye located at E = (0, -4), and the view is being projected on the one-dimensional “screen”, which is simply the x-axis. On the x-axis, A' is the projection of A, P' is the projection of P and so on. The distance AP is given by l and the distance A'P' is given by t. The quantity t relates to l as

\[
\begin{align*}
A & : t = 2l/(l + 5) \\
B & : t = l/(l + 4) \\
C & : t = 3l/(l + 8) \\
D & : t = 3l/(l + 9) \\
E & : t = l/(l + 2) \\
F & : t = 2l/(l + 10)
\end{align*}
\]

**Question 13 [4 points]** Why is the factor we use for distance attenuation $1/r^2$?

A. The volume of a sphere is proportional to $1/r^2$.
B. The volume of a sphere is proportional to $r^2$.
C. The photon density on the surface of a sphere is proportional to $r^2$.
D. The area of a sphere is proportional to $1/r^2$.
E. The area of a sphere is proportional to $r^2$.

**Question 14 [6 points]** Take two points on the two-dimensional $(x, y)$ plane: A = (1, 2) and B = (2, 3). Also consider a third point P = (1, 5), from which you drop a perpendicular on to the line AB, intersecting it at point S. The co-ordinates of S and the **implicit form** equation for the line AB are respectively given by

\[
\begin{align*}
A & : (3, 7/2) \quad 3x - y - 1 = 0 \\
B & : (5/2, 4) \quad x - y + 1 = 0 \\
C & : (7/2, 5/2) \quad x + y - 1 = 0 \\
D & : (5/2, 7/2) \quad x - y + 1 = 0 \\
E & : (3, 4) \quad 2x - y + 1 = 0 \\
F & : (3, 7/2) \quad x - y - 1 = 0
\end{align*}
\]