Record multiple choice answers below

(1) (a) (b) (c) (d) (e) (f) (g)
(2) (a) (b) (c) (d) (e) (f) (g)
(3) (a) (b) (c) (d) (e) (f) (g)
(4) (a) (b) (c) (d) (e) (f) (g)
(5) (a) (b) (c) (d) (e) (f) (g)
(6) (a) (b) (c) (d) (e) (f) (g)

(7) (a) (b) (c) (d) (e) (f) (g)
(8) (a) (b) (c) (d) (e) (f) (g)
(9) (a) (b) (c) (d) (e) (f) (g)

(10) (a) (b) (c) (d) (e) (f) (g)
(11) (a) (b) (c) (d) (e) (f) (g)
(12) (a) (b) (c) (d) (e) (f) (g)
(13) (a) (b) (c) (d) (e) (f) (g)
The exam will consist of at least 2 and no more than 4 “show your work questions” and a larger number of multiple choice questions.

**Multiple Choice Section:** circle correct answer

(1) If the dot product $\mathbf{a} \cdot \mathbf{a} = 16$, then the magnitude of $\mathbf{a}$ equals:
   (a) 8   (b) 4   (c) 16   (d) 256   (e) none of these.

(2) If the magnitude of $\mathbf{a}$ equals 16, then the dot product $\mathbf{a} \cdot \mathbf{a}$ equals:
   (a) 8   (b) 4   (c) 16   (d) 256   (e) none of these.

(3) The cross product $\mathbf{a} \times \mathbf{b}$ of $\mathbf{a} = < 2, 4, 4 >$ and $\mathbf{b} = < 2, 1, 2 >$ is
   (a) $< 2, 2, -3 >$   (b) $< -2, -2, 3 >$   (c) $< 6, 6, -9 >$   (d) $< 4, 4, -6 >$
   (e) none of these.
(4) The cosine of the angle between the two planes \(-x + 0y + 5z = 6\) and \(4x + 0y + 3z = 5\) is (rationalize the denominator)

(a) \(\frac{1}{3}\sqrt{26}\)  
(b) \(\frac{11}{130}\sqrt{13}\)  
(c) \(\frac{11}{65}\sqrt{26}\)  
(d) \(\frac{11}{130}\sqrt{26}\)  
(e) none of these.

(5) The displacement vector (also called the directed line segment) from \(P(1, -2, 2)\) to \(Q(2, 1, 4)\) is \(\vec{PQ} = \)

(a) \(<1, 2, 2>\)  
(b) \(<1, 3, 0>\)  
(c) \(<1, 3, 2>\)  
(d) \(<2, 2, 2>\)  
(e) none of these.

(6) The magnitude of \(a = < -1, 0, 2 >\) is

(a) 5  
(b) \(\sqrt{10}\)  
(c) 3  
(d) \(\sqrt{5}\)  
(e) none of these.
(7) Suppose \( \mathbf{a}(3) = <1, 2, 3> \), \( \mathbf{a}'(3) = <1, 1, 1> \), \( \mathbf{b}(3) = <1, 0, 0> \), 
\( \mathbf{b}'(3) = <2, 1, 0> \). Then \( \frac{d}{dt}[\mathbf{a} \cdot \mathbf{b}]_{t=3} = 
\begin{align*}
\text{(a) } 5 & \quad \text{(b) } \sqrt{10} & \quad \text{(c) } 3 & \quad \text{(d) } \sqrt{5} & \quad \text{(e) none of these.}
\end{align*}

(8) Consider three points \( P, Q \) and \( R \) in space. If \( \overrightarrow{PQ} \times \overrightarrow{PR} = <6, 8, 0> \) then the area of the parallelogram spanned by \( \overrightarrow{PQ} \) and \( \overrightarrow{PR} \) is:
\begin{align*}
\text{(a) } 3 & \quad \text{(b) } 5 & \quad \text{(c) } 7 & \quad \text{(d) } 10 & \quad \text{(e) none of these.}
\end{align*}
(9) Which line is parallel (not normal) to the plane \(2x + 2y + 4z + 7 = 0\):
(a) \(x = x_0 + 2t, y = y_0 + 2t, z = z_0 + 4t\)
(b) \(x = x_0 + 3t, y = y_0 - 5t, z = z_0 + t\)
(c) \(x = x_0 + 2t, y = y_0 + 2t, z = z_0 + t\)
(d) none of these.

(10) The scalar component of the projection of \(u = \langle -1, 7, 7 \rangle\)
onto \(v = \langle 1, 2, 2 \rangle\) is \(\text{comp}_v u = \)
(a) 9  (b) 4/3  (c) 2  (d) 3  (e) none of these.
(11) Suppose that \( \mathbf{r}(t) = < \cos(t), \sin(t), \sqrt{8} > \). Then the \textit{speed} is
(a) \( \sqrt{8} + 1 \)  \hspace{1cm} (b) \ 8 \hspace{1cm} (c) \ 2 \hspace{1cm} (d) \ 3 \hspace{1cm} (e) \text{none of these.}

(12) Suppose that \( \mathbf{r}'(t) = \mathbf{v}(t) = < 1, 5 > \) and that \( \mathbf{r}(1) = < 6, 7 > \). Then \( \mathbf{r}(t) = < x(t), y(t) > \) where the \textit{j} component is
(a) \( y(t) = 5t - 2 \)  \hspace{1cm} (b) \( y(t) = 5t + 5 \) \hspace{1cm} (c) \( y(t) = 5t + 2 \)
(d) \( y(t) = 5t - 4 \)  \hspace{1cm} (e) \( y(t) = 5t + 7 \) \hspace{1cm} (f) \text{none of these.}

(13) If the position vector of a particle is \( \mathbf{r}(t) = < \cos(t), \sin(t), \sqrt{3}t > \) then the arc-length of the path of the particle from \( t = 1 \) to \( t = 4 \) is
(a) \( 6 \)  \hspace{1cm} (b) \ 3 \hspace{1cm} (c) \ 5 \hspace{1cm} (d) \ 4 \hspace{1cm} (e) \text{none of these.}
(1) Find parametric equations of the line containing the points \( P(3, 1, -2) \) and \( Q(1, 3, 2) \) and determine if it is parallel to the plane with equation 
\[
4x - 3y + 5z = 1.
\]
If not find the point of intersection. \((7/3, 5/3, -2/3)\)

(2) Show that the two planes, \( x - 2y + 3z = 4 \), \( 2x - z = 1 \), are not parallel and find a parametric representation for the line of intersection. \( x = 2t + 1, \ y = 7t, \ z = 4t + 1 \)
(3) Suppose that \( \mathbf{v} = <2, 0, 2> \), if \( \text{comp}_v \mathbf{u} = 7 \), then find \( \text{proj}_v \mathbf{u} \)

(4) The acceleration of a particle moving in space is given by

\[
\mathbf{a}(t) = e^t \mathbf{i} - 2\mathbf{j} + \cos t \mathbf{k}.
\]

Find the velocity and speed of the particle if \( \mathbf{v}(0) = -\mathbf{i} + \mathbf{j} \). Then find the position \( \mathbf{r}(t) \) if its initial position is given by \( \mathbf{r}(0) = 3\mathbf{i} + \mathbf{j} - \mathbf{k} \).
(5) The position vector of a moving particle is given by

\[ \mathbf{r}(t) = \langle \sin 3t, 2t, \cos 3t \rangle; \]

Find:

(i) The velocity at \( t = \pi/4 \).
(ii) Parametric equations of the tangent line at \( t = \pi/4 \).
(iii) The unit tangent vector \( \mathbf{T}(t) \).
(iv) The curvature \( \kappa \).
(v) The unit normal vector \( \mathbf{N} \).
(6) Consider the circle of radius 5 centered at the origin.
   (a) Find the unit tangent $T$ at $(3, 4)$
   (b) Find the unit normal $N$ at $(3, 4)$
   (c) Find the curvature $\kappa$ at $(3, 4)$.
   (d) Sketch the circle and indicate $T$ and $N$ on your graph.