Standard Questions
1. Use the points $P(1, -1, 3)$, $Q(2, 2, 1)$, $R(-1, 2, 4)$, $S(4, 2, 1)$.
   (a) Find the midpoint between $P$ and $Q$
   (b) Find the distance between $P$ and $Q$
   (c) Find the angle between $\overrightarrow{PQ}$ and $\overrightarrow{PR}$
   (d) Parameterize the line segment $PQ$
   (e) Find the equation of the line $L$ that goes through $P$ and $Q$
   (f) Find the distance of $L$ from the origin
   (g) Find the distance of $L$ from the point $S$
   (h) Find the equation of the plane $\Pi$ through $P$, $Q$, $R$
   (i) Find the distance of $\Pi$ from the origin
   (j) Find the distance of $\Pi$ from the point $S$
   (k) Find the intersection of $\Pi$ with the plane $x - 2y + z = 3$
   (l) Find the angle between $\overrightarrow{PS}$ and $\Pi$
   (m) Find the equation of the line through $S$ which is perpendicular to $\Pi$
   (n) Find the point where $L$ intersects $\Pi$
   (o) Find the area of the triangle $PQR$
(p) Find the component of $\overrightarrow{PS}$ in direction $\overrightarrow{PQ}$

(q) Find the volume of the parallelepiped spanned by $\overrightarrow{PQ}, \overrightarrow{PR}, \overrightarrow{PS}$

2.
(a) The points $(2, 1, 3)$ and $(0, 3, 1)$ form a diameter of a sphere. Find its equation.

(b) Describe and classify the following quadratic surfaces:

\[
\begin{align*}
z^2 - x^2 - y^2 &= 1 \\
z^2 - x^2 + y^2 &= 1 \\
z^2 + x^2 - y^2 &= 0 \\
z^2 + x^2 - y &= 0
\end{align*}
\]

3. Do problem 5 (a), page 722.

**Advanced Questions**

4. Use the setup of problem 1.
(a) Find the volume of the tetrahedron $PQRS$

(b) Find the projection of $\overrightarrow{PS}$ into the plane $\Pi$

5. For the sphere from problem 2(a), find the equation of the tangent plane at $(2, 1, 3)$

6. Find the coordinates of the vector obtained by rotating the vector $(1, 2)$ by $40^\circ$ counterclockwise

7. Find the shortest distance between the lines

\[
\vec{r}(t) = \begin{pmatrix} 1 \\ 2 \\ -1 \end{pmatrix} + t \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix} \quad \text{and} \quad \vec{r}(s) = \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix} + s \begin{pmatrix} 3 \\ -1 \\ -2 \end{pmatrix}.
\]

8. Find the point where the planes $x - y + z = 0$, $2x - y + 2z = 1$ and $x + 2y - z = 7$ intersect