Please state clearly all assumptions made in order for full credit to be given.

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Problem #1 (25)

Consider the four points \(A(-6, 2, 4), B(2, -3, 7), C(10, 7, -9)\) and \(D(x, y, z)\) in a 3D Cartesian coordinate system.

(a) Express vector \(\mathbf{AB}\) in a Cartesian vector form. (4)

(b) Express vector \(\mathbf{AC}\) in a Cartesian vector form. (4)

(c) Point \(D\) is at the diagonal of the parallelogram \(ABDC\). Determine \(x, y\) and \(z\). (6)

(d) Find the magnitudes \(|\mathbf{AB}|, |\mathbf{AC}|\) and \(|\mathbf{AD}|\). (6)

(e) Find the angle between \(\mathbf{AB}\) and \(\mathbf{AD}\). Provide your result in degrees. (5)

\[
\begin{align*}
a) & \quad \mathbf{AB} = \\
b) & \quad \mathbf{AC} = \\
c) & \quad x = \\
& \quad y = \\
& \quad z = \\
d) & \quad |\mathbf{AB}| = \\
& \quad |\mathbf{AC}| = \\
& \quad |\mathbf{AD}| = \\
e) & \quad \theta =
\end{align*}
\]
**Problem #2 (25)**

Two forces are applied on a particle O as shown in the figure below. The angles $\alpha$, $\beta$ and $\gamma$ are the coordinate direction angles of $\mathbf{F}_1$.

(a) Express the forces $\mathbf{F}_1$ and $\mathbf{F}_2$ in a Cartesian vector form. (9)
(b) Find the resultant force $\mathbf{F}_R$ in a Cartesian vector form. (2)
(c) Find the unit vector from O to P, $\mathbf{u}_{OP}$. (4)
(d) Find the vector component of $\mathbf{F}_R$ along OP, $\mathbf{F}_{R//OP}$. (6)
(e) Find the vector component of $\mathbf{F}_R$ perpendicular to OP, $\mathbf{F}_{R\perp OP}$. (4)

![Diagram of forces and angles](image)

- $|\mathbf{F}_1| = 50 \text{ kN}$
- $|\mathbf{F}_2| = 75 \text{ kN}$
- $\gamma = 45^\circ$
- $\beta = 120^\circ$
- $\alpha = 60^\circ$
- $\mathbf{O} (0, 0, 0)$
- $\mathbf{P} (4, 3, 0)$

\[
\begin{align*}
\mathbf{F}_1 &= \\
\mathbf{F}_2 &= \\
\mathbf{F}_R &= \\
\mathbf{u}_{OP} &= \\
\mathbf{F}_{R//OP} &= \\
\mathbf{F}_{R\perp OP} &= 
\end{align*}
\]
Problem #3 (25)

In a ship-loading operation, a 3,500-lb. automobile is supported by a cable $AB$. A rope is tied to
the cable at $A$ and pulled in order to center the automobile over its intended position. The angle
between cable $AB$ and the vertical is $2^\circ$, while the angle between the rope $AC$ and the horizontal
is $30^\circ$.

a) Identify the particle to be analyzed  

b) Draw a FBD of the particle to be analyzed showing all the forces acting on it.  

c) Determine the magnitude of the force in cable $AB$ and in the rope $AC$ 

\[
\begin{array}{c|c|c}
\text{a)} \\
\text{b) FBD} \\
\text{c)} \text{ Value } & \text{ Unit} \\
T_{AB} &= \\
T_{AC} &= 
\end{array}
\]
Problem #4 (25)

Solve the following system of linear equations using the Gauss-Jordan Elimination method:
\[-x + 3y + 2z = 20\]
\[2x - y + 4z = -7\]
\[4x + 2y - 3z = -5\]

a) Write the **augmented matrix** (5)

b) Use elementary row operations to obtain the **reduced row echelon form** (17)

c) Write the solution for the three variables \(x\), \(y\), and \(z\) (3)

Show all details of the elementary row operations (no credit will be given for unsupported answers).

\[
\begin{align*}
\text{a)} \\
\text{c)}
\end{align*}
\]
\[
\begin{align*}
x &= \\
y &= \\
z &=
\end{align*}
\]