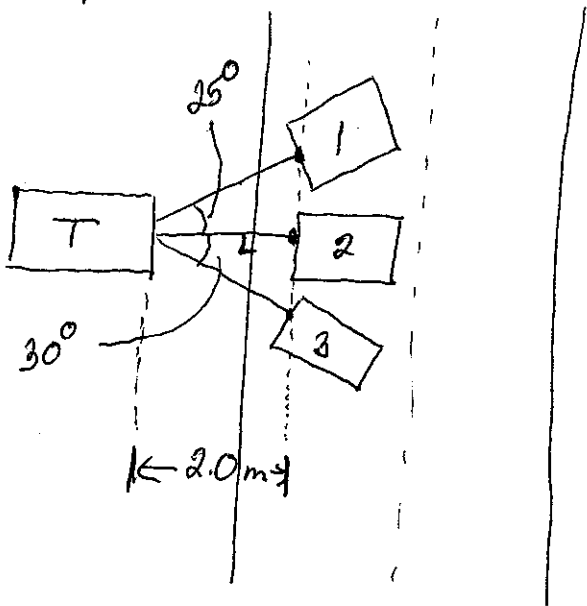


To pull a stuck tractor out of a ditch 3 pickup trucks are attached via cables to the tractor. Determine the resulting force acting on the tractor.

Top View



Let the connecting point on the tractor be 40cm below the road surface plane.

Truck 1

Pulls with $F = 4500\text{ N}$
 Hitch attached 60cm above road plane

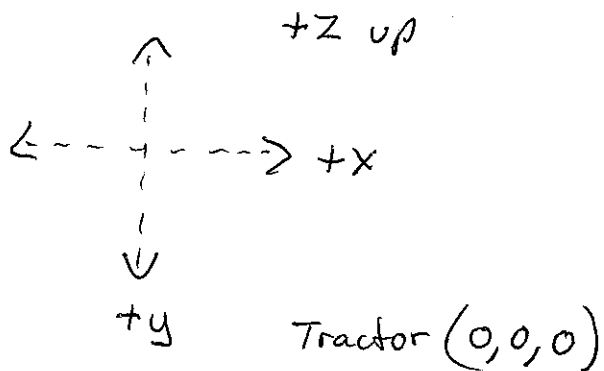
Truck 2

Pulls with $F = 5700\text{ N}$
 Hitch attached 50cm above road plane

Truck 3

Pulls with $F = 4700\text{ N}$
 Hitch attached 40cm above road plane

Use this coordinate system:

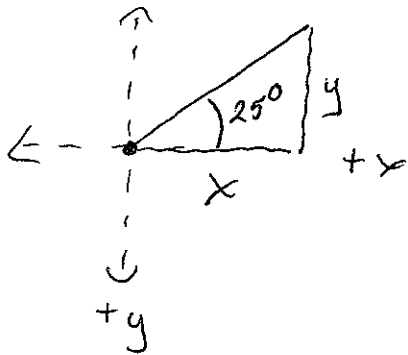


Solution Steps

(2)

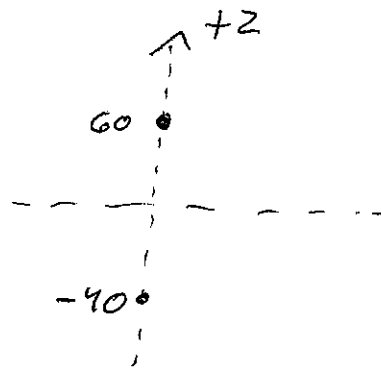
- 1) Define a direction vector for each force.
- 2) Determine the unit vector in that direction.
- 3) Define the force vector.
- 4) Add the force vectors.

Truck 1



$$x = 200 \text{ cm}$$

$$y = 200 \text{ cm} \tan 25^\circ \\ = 93.26 \text{ cm}$$



$$z = 100 \text{ cm}$$

$$\text{direction 1} \\ (\vec{d}_1) = 200 \text{ cm } \vec{x} + -93.26 \text{ cm } \vec{y} + 100 \text{ cm } \vec{z}$$

$$\text{Unit Vector 1} \\ (u_1) = \frac{\text{vector}}{\|\text{vector}\|}$$

(3)

$$\vec{u}_1 = \frac{\vec{d}_1}{\|\vec{d}_1\|}$$

$$\begin{aligned} \|\vec{d}_1\| &= \sqrt{(200\text{cm})^2 + (-93.26\text{cm})^2 + (100\text{cm})^2} \\ &= 242.3\text{cm} \end{aligned}$$

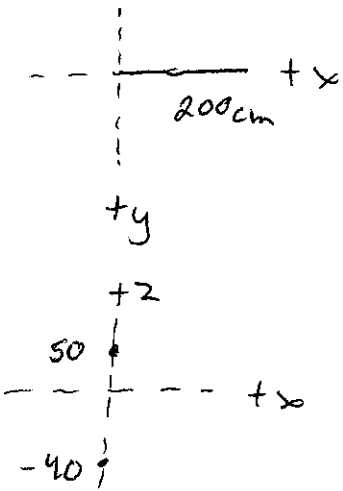
$$\vec{u}_1 = \frac{200\text{cm}}{242.3\text{cm}} \vec{x} + \frac{-93.26\text{cm}}{242.3\text{cm}} \vec{y} + \frac{100\text{cm}}{242.3\text{cm}} \vec{z}$$

$$\vec{u}_1 = 0.825 \vec{x} + -0.385 \vec{y} + 0.413 \vec{z}$$

$$\begin{aligned} \vec{F}_1 &= F \vec{u}_1 = 4500\text{N}(0.825) \vec{x} + 4500\text{N}(-0.385) \vec{y} + \\ & \quad 4500\text{N}(0.413) \vec{z} \end{aligned}$$

$$\vec{F}_1 = 3710\text{N} \vec{x} + -1780\text{N} \vec{y} + 1860\text{N} \vec{z}$$

Truck 2



$$x = 200 \text{ cm}$$

$$y = 0 \text{ cm}$$

$$z = 90 \text{ cm}$$

$$\vec{d}_2 = 200 \text{ cm } \vec{x} + 90 \text{ cm } \vec{z}$$

$$\begin{aligned} \|\vec{d}_2\| &= \sqrt{(200 \text{ cm})^2 + (90 \text{ cm})^2} \\ &= 219 \text{ cm} \end{aligned}$$

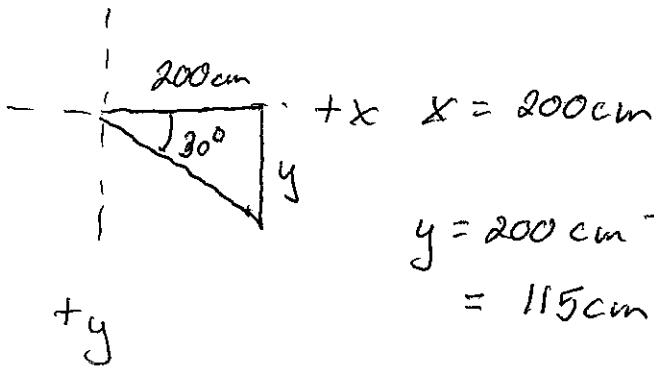
$$\vec{u}_2 = \frac{\vec{d}_2}{\|\vec{d}_2\|} = \frac{200 \text{ cm}}{219 \text{ cm}} \vec{x} + \frac{90 \text{ cm}}{219 \text{ cm}} \vec{z}$$

$$= 0.913 \vec{x} + 0.411 \vec{z}$$

$$\vec{F}_2 = F_2 (\vec{u}_2) = 5700 \text{ N} (0.913) \vec{x} + 5700 \text{ N} (0.411) \vec{z}$$

$$\vec{F}_2 = 5200 \text{ N } \vec{x} + 2340 \text{ N } \vec{z}$$

Truck 3

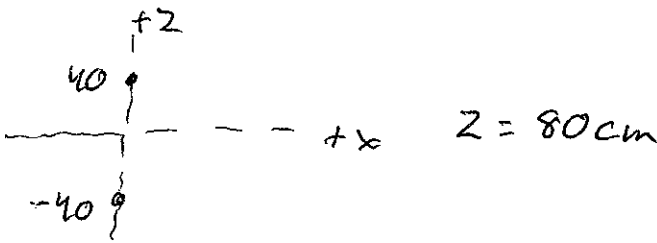


$$\vec{d}_3 = 200 \text{ cm } \vec{x} + 115 \text{ cm } \vec{y} + 80 \text{ cm } \vec{z}$$

$$\|\vec{d}_3\| = \sqrt{(200 \text{ cm})^2 + (115 \text{ cm})^2 + (80 \text{ cm})^2}$$

$$= 244 \text{ cm}$$

$$y = 200 \text{ cm } \tan 30^\circ = 115 \text{ cm}$$



$$\vec{u}_3 = \frac{\vec{d}_3}{\|\vec{d}_3\|} = \frac{200 \text{ cm}}{244 \text{ cm}} \vec{x} + \frac{115 \text{ cm}}{244 \text{ cm}} \vec{y} + \frac{80 \text{ cm}}{244 \text{ cm}} \vec{z}$$

$$= 0.820 \vec{x} + 0.471 \vec{y} + 0.328 \vec{z}$$

$$\vec{F}_3 = F_3 (\vec{u}_3) = 4700 \text{ N} (0.820) \vec{x} + 4700 \text{ N} (0.471) \vec{y} + 4700 \text{ N} (0.328) \vec{z}$$

$$\vec{F}_3 = 3850 \text{ N } \vec{x} + 2210 \text{ N } \vec{y} + 1540 \text{ N } \vec{z}$$

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	\vec{x}	\vec{y}	\vec{z}
F_1	3710 N	-1730 N	1860 N
F_2	5200 N	0	2340 N
F_3	3850 N	2210 N	1540 N
<hr/>			
F_{net}	12760 N	480 N	5740 N

$$F_{net} = 12760 N \vec{x} + 480 N \vec{y} + 5740 N \vec{z}$$