30 Minutes, Closed Book, Closed Notes,
- Please show all work on the front of the quiz sheets (work on the back will not be considered), extra paper will be provided upon request;
- Please clearly indicate your final answers;
- For credit, you must show calculations that support your answers.

The following expressions may be of use:

\[ \tan \theta = \frac{\sin \theta}{\cos \theta} \]

\[ \mathbf{F} = \mathbf{F} \mathbf{\lambda} \]

\[ \mathbf{F} = (F \cos \theta_x)\hat{i} + (F \cos \theta_y)\hat{j} + (F \cos \theta_z)\hat{k} \]

\[ \mathbf{F} = \frac{F}{d} \frac{d}{d} \hat{i} + \frac{F}{d} \frac{d}{d} \hat{j} + \frac{F}{d} \frac{d}{d} \hat{k} \]

\[ \mathbf{M} = \mathbf{r} \times \mathbf{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \tau_x & \tau_y & \tau_z \\ F_x & F_y & F_z \end{vmatrix} \]

\[ \mathbf{M} = rF \sin \theta \]

\[ \mathbf{M} = dF \]
Problem 1 (10 points)

A pole is tethered to two cables attached to the ground at points C and D that lie in the xz plane. The magnitude of the force $F$ applied at point A is 800 lb with its line of action passing through point D. The angle $\theta$ is measured in the xz plane. With reference to the coordinate system given:

1. (4 points) If $\theta$ is equal to 30°, express the force $F$ in its Cartesian vector form (i.e. in terms of components and unit vectors). Your answer must include the appropriate units.

$$\theta = 30^\circ$$

$$\alpha = 13.856 \text{ ft}$$

$$d_x = 13.856$$

$$d_y = -4$$

$$d_z = 3$$

$$\frac{8 \text{ ft}}{\alpha} = 4 \sin 30^\circ$$

$$d = \sqrt{(13.856^2) + (-4^2) + 3^2} = 26.4 \text{ ft}$$

$$F_x = 13.856/26.4 \times (800 \text{ lb}) = 419.9 \text{ lb}$$

$$F_y = (-4/26.4) \times (800 \text{ lb}) = -636.4 \text{ lb}$$

$$F_z = (3/26.4) \times (800 \text{ lb}) = 242.4 \text{ lb}$$
2. (3 points) Find the resultant of the two forces applied at point A in Cartesian vector form. Your answer must include the appropriate units.

\[ d_x = -12 \]
\[ d_y = -21 \]
\[ d_z = 16 \]
\[ d = \sqrt{(-12)^2 + (-21)^2 + 16^2} \]
\[ d = 29 \]
\[ F_1 = \left(\frac{12}{29}\right)(580)\hat{i} + \left(\frac{-21}{29}\right)(580)\hat{j} + \left(\frac{16}{29}\right)(580)\hat{k} \]
\[ F_2 = -240\hat{i} - 420\hat{j} + 320\hat{k} \text{ lb} \]
\[ R = 179.9\hat{i} - 1056.4\hat{j} + 562.4\hat{k} \text{ lb} \]

3. (3 points) Find the angle that the resultant makes (in degrees) with the x axis.

\[ R = \sqrt{(179.9^2) + (-1056.4^2) + (562.4^2)} \]
\[ R = 1210.2 \text{ lb} \]
\[ \cos \theta_x = \frac{179.9}{1210.2} \]
\[ \theta_x = \cos^{-1}(0.14865) \]
\[ \therefore \theta_x = 81.45^\circ \]
Problem 2 (10 points)

\[ A_{D \text{lb}} \cos 15^\circ = 38.637 \text{ lb} \]

\[ F = 40 \text{ lb} \]

\[ 40 \text{ lb} \sin 15^\circ = 10.353 \text{ lb} \]

\[ l \sin 50^\circ \]

A pry bar is being used to extract a nail at point C. The magnitude of the force \( F \) applied to the pry bar at point A is 40 lb and \( \theta \) is equal to 15°. What would be the minimum length of the pry bar arm (point A to B) to produce a clockwise moment of 800 lb-in about point B?

\[ (4) \quad M_B = 10.353 \text{ lb} \cdot \min(50^\circ) - (38.637 \text{ lb})(l \sin 50^\circ) = -800 \]

\[ 6.655 l_{\min} - 29.598 l_{\min} = -800 \]

\[ l_{\min} = 34.9 \text{ in} \]

Also

\[ M_B = rF \sin \theta \]

\[ -800 \text{ lb-in} = (l)(40 \text{ lb})(\sin (145^\circ)) \]

\[ l_{\min} = 34.9 \text{ in} \]
Problem 3 (10 points)

A tank hangs in equilibrium from two cables attached at a connecting ring at point A.

1. (3 points) Draw a Free Body Diagram of point A in the box below. For full credit, show all known and unknown forces and clearly indicate the directions of each force.
2. (4 points) Find the angle \( \theta \) (in degrees) that the 150 lb force makes with the horizontal.
\[ +z \sum F_x = 0 \]
\[ -150 \cos \theta + (120 \text{ lb}) \cos 30^\circ = 0 \]
\[ -150 \cos \theta + 103.92 = 0 \]
\[ \cos \theta = 0.683 \]
\[ \theta = 46.1^\circ \]

3. (3 points) Find the weight of the tank. Your answer must include the appropriate units.
\[ +z \sum F_y = 0 \]
\[ -150 \sin \theta - 100 \sin 30^\circ - W = 0 \]
\[ 108.14 + 60 - W = 0 \]
\[ W = 168.1 \text{ lb} \]