$\frac{29\frac{1}{2}}{30}$ Nice work!

Name: [redacted] Discussion Section: [redacted]

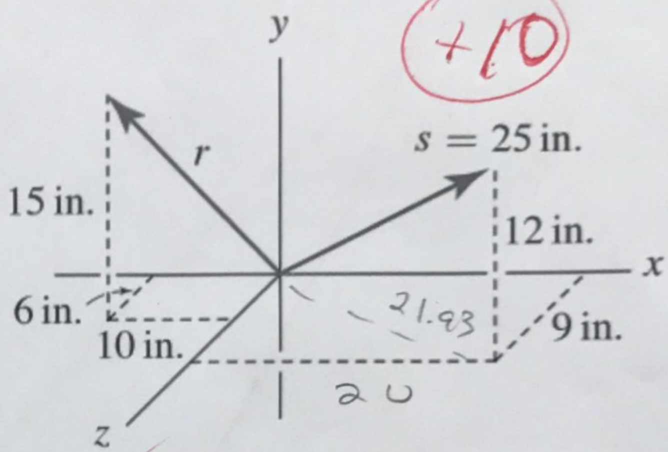
EMA 201 Exam #1

October 11h, 2017

This exam is closed book and closed notes except for the attached equation sheet. Each problem is equally weighted. All work must be shown, ***including free body diagrams where appropriate***.

+10

1. Position vectors $\vec{r}$ and $\vec{s}$ are shown in the figure to the right.
   (a) Find the resultant of these two vectors and the direction angles of the resultant.
   (b) Determine the angle between vectors $\vec{r}$ and $\vec{s}$.
   (c) Find a unit vector perpendicular to $\vec{r}$ and $\vec{s}$ and having a positive $\hat{j}$ component.



a)

$\vec{r} = -10\hat{i} + 15\hat{j} + 6\hat{k} = 19$

$\vec{s} = 20\hat{i} + 12\hat{j} + 9\hat{k} = 25$

$\vec{R} = \vec{r} + \vec{s} = 10\hat{i} + 27\hat{j} + 15\hat{k} = 32.46 \Rightarrow \theta_x = 72.06°, \theta_y = 33.72°, \theta_z = 62.48°$

b) $\vec{r} \cdot \vec{s} = -200 + 180 + 54 = 34 = (19)(25)\cos\theta$

$.0758 = \cos\theta$

$\theta = 85.89°$

c) $\vec{s} \times \vec{r} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -10 & 15 & 6 \\ -20 & 12 & 9 \end{vmatrix}$

$(135 - 72)\hat{i} + (120 + 90)\hat{j} + (-300 + 120)\hat{k}$

$\frac{-63\hat{i} + 210\hat{j} - 420\hat{k}}{473.8}$

$\hat{u} = .1330\hat{i} + .4432\hat{j} - .8864\hat{k}$

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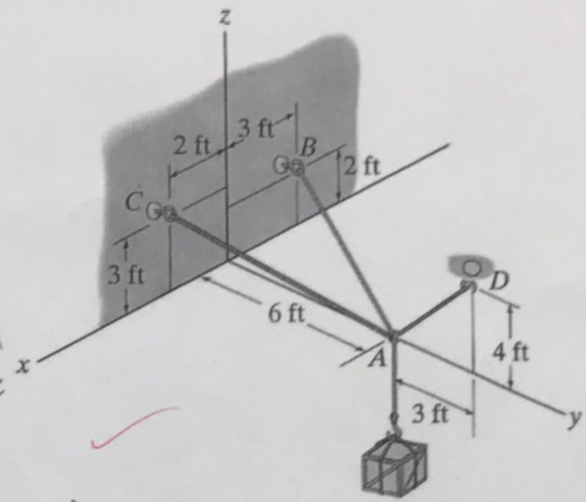
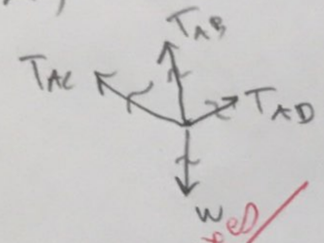
$\frac{9\,1/2}{10}$

2. A crate is supported by three cables as shown in the figure. Determine the maximum weight of the crate that can be suspended in this geometry so that the tension in any one of the cables does not exceed 250 lb.



A)



show axes ✓ +2

$$\hat{U}_{AC} = \frac{2\hat{i} - 6\hat{j} + 3\hat{k}}{7}$$ ✓

$$\hat{U}_{AB} = \frac{-3\hat{i} - 6\hat{j} + 2\hat{k}}{7}$$ ✓

$$\hat{U}_{AD} = \frac{3\hat{j} + 4\hat{k}}{5}$$ ✓ +3

$$\Sigma F_x: \frac{2}{7}T_{AC} - \frac{3}{7}T_{AB} = 0 \Rightarrow \frac{2}{3}T_{AC} = T_{AB}$$ ✓

$$\Sigma F_y: \frac{3}{5}T_{AD} - \frac{6}{7}T_{AC} - \frac{6}{7}T_{AB} = 0 \Rightarrow \frac{3}{5}T_{AD} = \frac{30}{21}T_{AC} \Rightarrow T_{AD} = \frac{50}{21}T_{AC}$$ ✓

$$\Sigma F_z = \frac{3}{7}T_{AC} + \frac{2}{7}T_{AB} + \frac{4}{5}T_{AD} - W = 0$$ ✓ +3

$$\frac{9}{21}T_{AC} + \frac{4}{21}T_{AC} + \frac{40}{21}T_{AC} = W$$

$$\frac{53}{21}T_{AC} = W$$

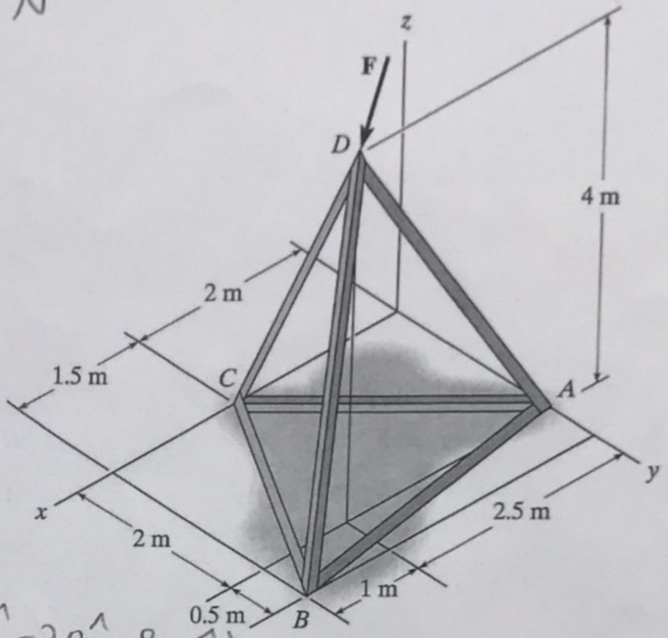
$$T_{AC} = \frac{21}{53}W, \quad T_{AD} = \frac{50}{53}W, \quad T_{AB} = \frac{14}{53}W \Rightarrow \boxed{66.04\text{ lb}}$$

+1 1/2   99.06 lb   235.8 lb

You have to multiply $T_{AB} = 250$ by 53/21, & so on and then compare. You have substituted W = 250

10/10

3. A vector $\vec{F} = 50\hat{i} - 20\hat{j} - 80\hat{k}$ is N applied to the top of the tetrahedral cell at point D.
   (a) Obtain a vector expression for the moment of this force about point A.
   (b) Find magnitudes of the moment of this force about the base lines AC and AB of the cell.
   (c) What is the magnitude of the moment of this force about the line AD?



a)

$$\vec{M}_A = \vec{r}_{AD} \times \vec{F}$$

$$= (2.5\hat{i} + 4\hat{k}) \times (50\hat{i} - 20\hat{j} - 80\hat{k})$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2.5 & 0 & 4 \\ 50 & -20 & -80 \end{vmatrix}$$ (+1)

$$\vec{M}_A = 80\hat{i} + 400\hat{j} - 50\hat{k}$$ (+1) (+1) (+1)

b) $\hat{u}_{AC} \cdot \vec{M}_A$

$$\hat{u}_{AC} = \frac{2\hat{i} - 2\hat{j}}{2.828}$$ (+1.5)

$$(.7072\hat{i} - .7072\hat{j}) \cdot (80\hat{i} + 400\hat{j} - 50\hat{k})$$

$$= 56.58 - 282.9 = -226.3 \text{ N·m}$$ (+1)

$\hat{u}_{AB} \cdot \vec{M}_A$

$$\hat{u}_{AB} = \frac{3.5\hat{i} + .5\hat{j}}{3.535}$$ (+1.5)

$$(.9901\hat{i} + .1414\hat{j}) \cdot (80\hat{i} + 400\hat{j} - 50\hat{k})$$

$$= 79.21 + 56.56 = \boxed{135.8 \text{ N·m}}$$ (+1)

c) $$\hat{u}_{AD} = \frac{2.5\hat{i} + 4\hat{k}}{4.717}$$

$$(.5300\hat{i} + .8480\hat{k}) \cdot (80\hat{i} + 400\hat{j} - 50\hat{k})$$

$$42.40 - 42.40 = 0 \text{ N·m}$$ (+1)

Excellent!