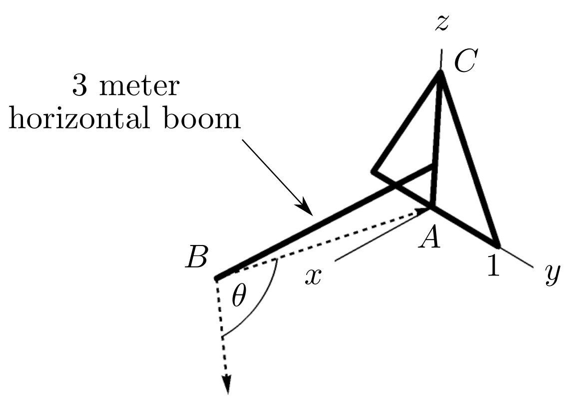
1. (12.3.6) The boom on a crane is constructed of steel pipes drawn with the thick lines in the schematic drawing below. The triangular support is an equilateral triangle of side length 2 meters in the y, z-plane as indicated in the drawing. The boom is 3 meters long and extends horizontally orthogonal to the y, z-plane from the centroid of the triangle. The cable passes through points $A = (0, 0, 0)$ and B and hangs down vertically from B as indicated by the dashed vectors. Note: The **centroid** of an equilateral triangle is the intersection of the medians, the intersection of the angle bisectors, and the intersection of the altitudes. (These are all the same point for an equilateral triangle.) A **median** of a triangle is the line segment joining a vertex with the midpoint of the opposite side.



(a) (7 points) Find the distance from B to C in meters.

(b) (8 points) Find the cosine of the angle θ between the two straight portions of the cable.

(c) (10 points) Let $\mathbf{v}$ be the vector displacement from C to B, and let $\mathbf{w}$ be the vector displacement from C to $(0, 1, 0)$. Find $\mathbf{v} \times \mathbf{w}$.

Name and section: ___________________

2. (quadric surfaces) Sketch the quadric surfaces in $\mathbb{R}^3$ associated with the relations:

   (a) (15 points) $x^2 - 16y^2 - 4z^2 = 64$

   (b) (10 points) $z = -2x^2$

Name and section: ____________________

3. (25 points) (13.2.16) Solve the initial value problem for the vector valued function $\mathbf{r}$.

$$\begin{cases} \mathbf{r}' = (t/(t^2+2), (t+1)/(2-t), (t^2+4)/(t^2+3)) \\ \mathbf{r}(0) = (3, -2, 1). \end{cases}$$

Remember the indefinite integral $\int 1/(\tau^2+1)\, d\tau = \tan^{-1}\tau + C$.

Name and section: ____________________

4. (motion along a helix) A point mass moves along a cylinder with position given as a function of time by

$$\mathbf{r}(t) = (5\cos\theta, -5\sin\theta, t/2)$$

where $\theta = \theta(t)$.

(a) (10 points) Find the velocity and acceleration on the mass.

(b) (10 points) Assuming $\theta(t) = t$, draw a picture of the path of the point mass.

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5. (Bonus 10 points) (curvature) Find the curvature of the path parameterized by

$$\mathbf{r}(t) = (5\cos t, -5\sin t, t/2).$$