NAME: ______________________________    Section: ___________

RIN: _______________________________

Wednesday, December 16, 2009

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N.B.: You will be graded on 5 problems, 20 points per problem. Problems 1, 2, and 3 are mandatory and will be graded. Before turning in your exam, please make sure you have circled the two problems you want to be graded out of problems 4, 5 and 6.
Problem 1 (20 points)
Given the system of linear algebraic equations:

\[
\begin{align*}
7x + 5y - 3z &= 10 \\
4x - 3y + 9z &= 0 \\
-x + 6y + 8z &= -5
\end{align*}
\]

a) Write the system of equations in a matrix form \( AX = B \). Identify \( X \), \( A \), and \( B \). (3 points)
b) Calculate \( \text{det}(A) \) using the method of cofactors by expanding the third row. (6 points)
c) Calculate \( \text{Adj}(A) \). (8 points)
d) Determine \( A^{-1} \). (3 points)
e) Use Cramer’s rule to solve the value of \( y \). (5 points)
Problem 2 (20 points)
A 100-lb crate is resting on a ramp as shown. The crate is connected on one side by a cable that passes over a fixed peg as shown and then supports a block of weight \( W \).
If the coefficient of static friction between the block and the ramp is 0.20 and between the cable and the peg is 0.30, determine;
   a) The minimum weight of the block for which no motion occurs (10 points)
   b) The maximum weight of the block for which no motion occurs (10 points)

Note: You need to show all FBD’s required to solve the problem and all calculations to receive full credit.
In the above figure, a 300 N horizontal beam is suspended from the ceiling using two cables. A distributed load is placed on the beam, indicated by the shaded area in the figure. The ‘missing’ section on the left side is a half circle. A weight per unit length of 400 N/m is located at the center of the beam and at point A.

In the follow questions, assume the origin is located at the left end of the beam.

(a) Determine the total weight (resultant) and x-centroid, $x_{c-load}$ (line of action), of the distributed load. (Ignore the beam weight for this calculation.) (15 points)
(b) If the cables are affixed to a ceiling at points A and B, determine the tension in each cable. You need to include a FBD. Your solution should include forces from the distributed load and the beam weight. (5 points)
Problem 4 (20 points)
A block has a mass \( m = 1000 \text{ kg} \) and is suspended from a three-cable arrangement as illustrated in the figure below. For a gravitational acceleration, \( g = 9.807 \text{ m/s}^2 \):

(a) Draw two complete and separate free body diagrams: one for the block and the other for the joint at point A. (4 points)

(b) Write the equilibrium equations for each diagram. (4 points)

(c) For the case where \( \alpha = 30^\circ \) and \( \beta = 45^\circ \), determine the tensions in cables T1, T2, and T3 (in N). (9 points)

(d) Can the system support the block if each one of the cables would break when the tension reaches 10,000 N? (3 points)
Problem 5 (20 points)
A rope ABG goes through a frictionless collar at point B; that is the tension in the cable is the same in segments AB and BG, is connected to three bars: BC, BD, and BE. Block G at the end of the rope has a weight of 50 N. The coordinates of different points are (in [cm]): A(0; 0; 70), B(50; 50; 70), C(0; 20; 0), D(70; 20; 20), and E(30; 80; 10). Find the forces in bars. Express your answers in Cartesian vector form.

Note: You need to show all FBD’s required to solve the problem and all calculations to receive full credit.
Problem 6 (20 points)
The frame in the figure is supported by smooth pins at points A and E, and the members are also connected by other smooth pins as shown.

a) Draw a free body diagram (FBD) for member EDC. Determine the value of the vertical component of the reaction at support E from the available equations (8 points)
b) Obtain from another FBD, the additional information you need to solve for EDC (8 points)
c) Determine the horizontal and vertical components of all forces acting on member EDC (4 points)

Note: Show all work and calculations
Circular arc

\[ L = 2r \alpha \]  
\[ x_C = \frac{r \sin \alpha}{\alpha} \]  
\[ y_C = 0 \]

Quarter circular arc

\[ L = \frac{\pi r}{2} \]  
\[ x_C = \frac{2r}{\pi} \]  
\[ y_C = \frac{2r}{\pi} \]

Semicircular arc

\[ L = \pi r \]  
\[ x_C = r \]  
\[ y_C = \frac{2r}{\pi} \]

Rectangular area

\[ A = bh \]  
\[ x_C = \frac{b}{2} \]  
\[ y_C = \frac{h}{2} \]

Triangular area

\[ A = \frac{bh}{2} \]  
\[ x_C = \frac{2b}{3} \]  
\[ y_C = \frac{h}{3} \]

Triangular area

\[ A = \frac{bh}{2} \]  
\[ x_C = \frac{a + b}{3} \]  
\[ y_C = \frac{h}{3} \]

Circular sector

\[ A = \frac{r^2 \alpha}{2} \]  
\[ x_C = \frac{2r \sin \alpha}{3\alpha} \]  
\[ y_C = 0 \]

Quarter of a circle

\[ A = \frac{\pi r^2}{4} \]  
\[ x_C = \frac{4r}{3\pi} \]  
\[ y_C = \frac{4r}{3\pi} \]

Semicircular area

\[ A = \frac{\pi r^2}{2} \]  
\[ x_C = r \]  
\[ y_C = \frac{4r}{3\pi} \]

Quadrant of an ellipse

\[ A = \frac{mb}{4} \]  
\[ x_C = \frac{4a}{3\pi} \]  
\[ y_C = \frac{4b}{3\pi} \]

Parabolic spandrel

\[ A = \frac{bh}{3} \]  
\[ x_C = \frac{2b}{4} \]  
\[ y_C = \frac{3b}{10} \]

Quadrant of a parabola

\[ A = \frac{2bh}{3} \]  
\[ x_C = \frac{5b}{8} \]  
\[ y_C = \frac{2b}{5} \]