Name _____ SID _____

Introduction to Solid Mechanics
ME C85/CE C30

Midterm Exam 2

Fall, 2012

1. Do not open this exam until you are told to begin.
2. Put your name and SID on **every** page.
3. You may not use a calculator, but you may use a straightedge to help you draw figures.
4. You may use one 8-1/2 x 11 sheet of notes, but not your book or any other notes.
5. Store everything else out of sight.
6. Turn off cell phones.
7. There will be no questions during the exam. Write your concerns or alternative interpretations in exam margins.
8. Write all answers in the space provided in this exam.
9. Be concise and write clearly. Identify your answer to a question by putting a box around it.
10. Use only the front sides of the answer sheets for your answers. You may use the backs of pages for "scratch" paper, but if there is work that we should see, be sure to point that out in the main body of the exam.
11. Time will be strictly enforced. At 9:00, you must put down your pencil or pen and immediately turn in your exam. Failure to do so may result in loss of points.

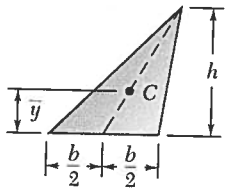
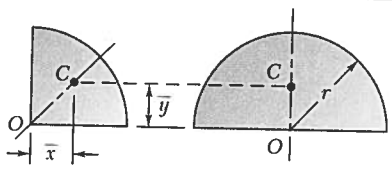
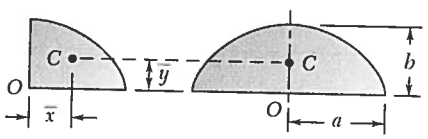
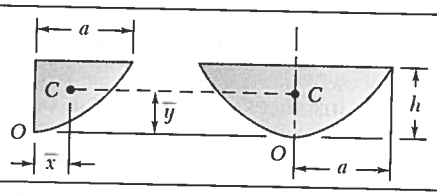
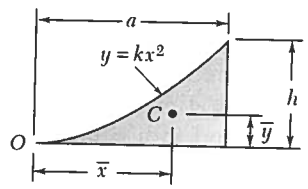
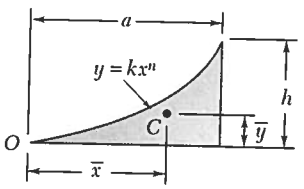
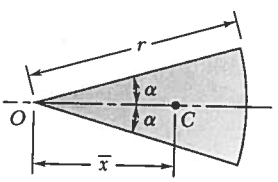
Shape		$\bar{x}$	$\bar{y}$	Area
Triangular area			$\frac{h}{3}$	$\frac{bh}{2}$
Quarter-circular area		$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{4}$
Semicircular area		0	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{2}$
Quarter-elliptical area		$\frac{4a}{3\pi}$	$\frac{4b}{3\pi}$	$\frac{\pi ab}{4}$
Semielliptical area		0	$\frac{4b}{3\pi}$	$\frac{\pi ab}{2}$
Semiparabolic area		$\frac{3a}{8}$	$\frac{3h}{5}$	$\frac{2ah}{3}$
Parabolic area		0	$\frac{3h}{5}$	$\frac{4ah}{3}$
Parabolic spandrel		$\frac{3a}{4}$	$\frac{3h}{10}$	$\frac{ah}{3}$
General spandrel		$\frac{n+1}{n+2}a$	$\frac{n+1}{4n+2}h$	$\frac{ah}{n+1}$
Circular sector		$\frac{2r\sin\alpha}{3\alpha}$	0	αr^2

Fig. 5.8A Centroids of common shapes of areas.

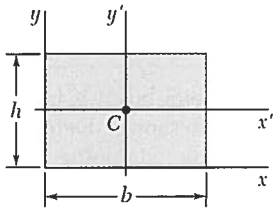
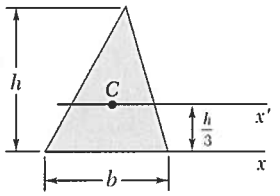
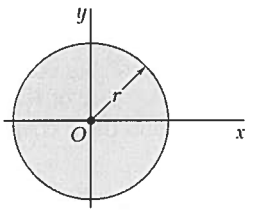
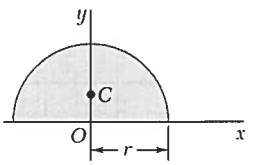
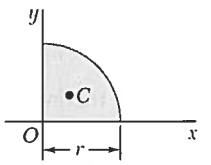
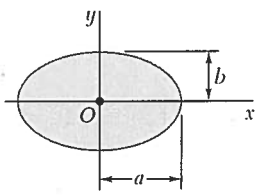
Rectangle		$\bar{I}_{x'} = \frac{1}{12}bh^3$ $\bar{I}_{y'} = \frac{1}{12}b^3h$ $I_x = \frac{1}{3}bh^3$ $I_y = \frac{1}{3}b^3h$ $J_C = \frac{1}{12}bh(b^2 + h^2)$
Triangle		$\bar{I}_{x'} = \frac{1}{36}bh^3$ $I_x = \frac{1}{12}bh^3$
Circle		$\bar{I}_x = \bar{I}_y = \frac{1}{4}\pi r^4$ $J_O = \frac{1}{2}\pi r^4$
Semicircle		$I_x = I_y = \frac{1}{8}\pi r^4$ $J_O = \frac{1}{4}\pi r^4$
Quarter circle		$I_x = I_y = \frac{1}{16}\pi r^4$ $J_O = \frac{1}{8}\pi r^4$
Ellipse		$\bar{I}_x = \frac{1}{4}\pi ab^3$ $\bar{I}_y = \frac{1}{4}\pi a^3b$ $J_O = \frac{1}{4}\pi ab(a^2 + b^2)$

Fig. 7.11 Moments of inertia of common geometric shapes.

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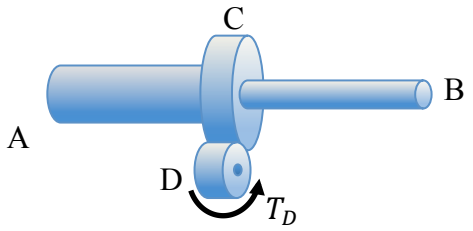
1. **(35 Points Total)** Two shafts AC and BC, both of length L and made of material with shear modulus G, are connected at gear C. Shaft BC has radius r, shaft AC has radius $2r$, and gear C has radius $4r$. The ends of the shafts at A and B are attached to rigid supports in a way that prevents rotation at those points. (Note that the end supports at A and B are not shown.) A torque T_D, positive in the direction shown, is applied to gear D, which has radius $2r$.

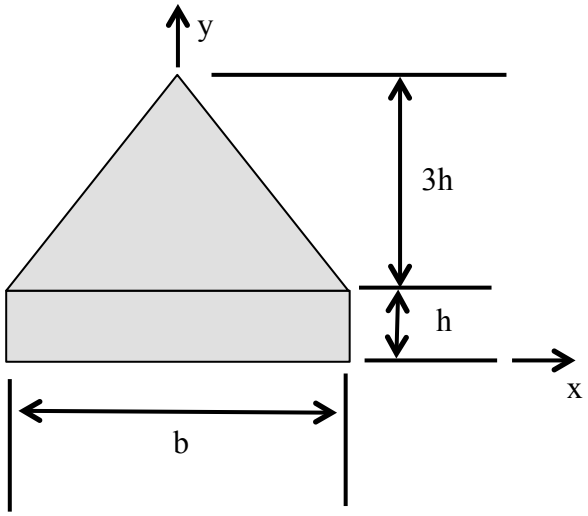
   a) **(15 Points)** Determine the reaction torques at A and B in order to prevent rotation at those points.
   b) **(15 Points)** Determine the rotation of gear C.
   c) **(5 Points)** Determine the rotation of gear D.



Problem 1 (continued)

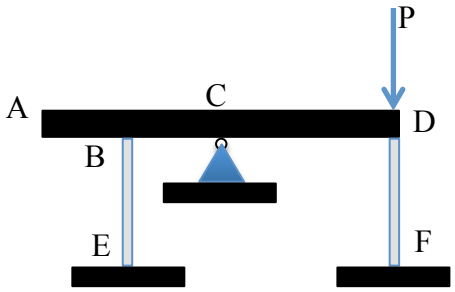
2. **(30 Points Total)** For the composite area shown:

   a) **(15 Points)** Determine the centroid, being sure to express your answer as the distance from the origin of the coordinate system shown.
   b) **(15 Points)** Determine the moment of inertia about the x axis (i.e., the base of the area).



Problem 2 (continued)

3. **(35 Points Total)** Member ABCD is a rigid link of total length $2L_1$ that is free to rotate about point C at its center. Point B is midway between points A and C. Members BE and DF are elastic bars, both of length L_2, cross sectional area A and elastic modulus E, that are attached to the rigid link at B and D, and are built into a rigid base at E and F. A point load of magnitude P is applied at point D.



a) **(20 Points)** Determine the stresses in bars BE and DF.
b) **(15 Points)** Determine the rotation angle that link ABCD experiences under this loading.

Problem 3 (continued)