MSE 222 DYNAMICS Midterm 1 Exam

SIMON FRASER UNIVERSITY

MECHATRONIC SYSTEMS ENGINEERING

Midterm 1 Examination – February 18, 2016

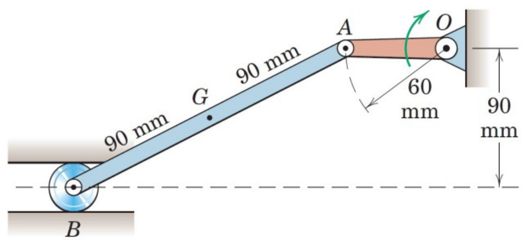
Instructor: Kambiz Hajikolaei | Time: 90 minutes

Non-programmable calculators may be used

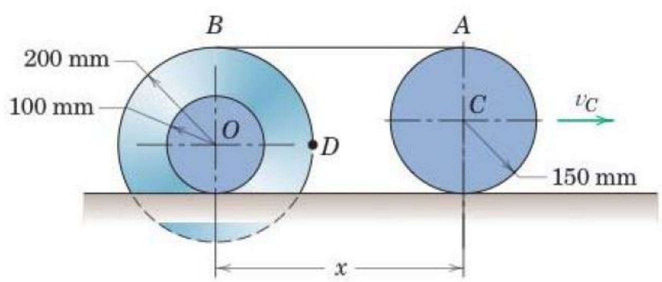
No smartphones or other electronic devices may be used

Answer all the questions in the booklet (not the question sheet)

Problem1: In the mechanism below, crank OA is rotating with constant angular velocity of ω. For the instant represented, when crank OA passes the horizontal position, determine the velocity of the center G of link AB by Instantaneous Center of Zero Velocity (IC) method, as a function of ω.



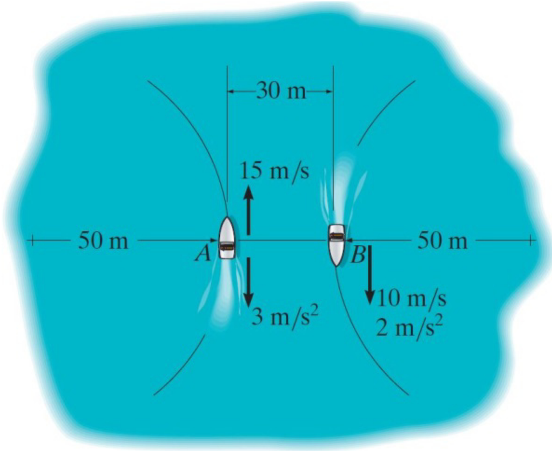
Problem2: Determine the magnitude of the acceleration of point D in the position shown if the center C of the smaller wheel has acceleration to the right of 0.8 $\frac{m}{s^2}$ and has reached a velocity of 0.4 $\frac{m}{s}$ at this instant. The cord which connects the two wheels is securely wrapped around the respective peripheries and does not slip.



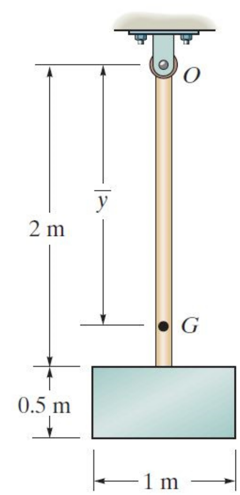
Problem3: At the instant shown, boat A travels with a speed of 15 m/s, which is decreasing at 3 m/s^2, while boat B travels with a speed of 10 m/s, which is increasing at 2 m/s^2.

- Determine the velocity and acceleration of boat A with respect to boat B at this instant.

- Determine the velocity and acceleration of boat B with respect to boat A at this instant.

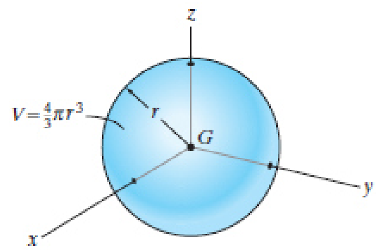


Problem4: The pendulum consists of the 3-kg slender rod and the 5-kg thin plate. Calculate the moment of inertia of the pendulum about an axis perpendicular to the page and passing through G (center of mass).



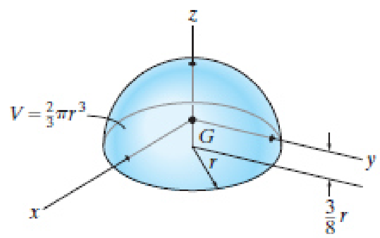
Kinematics Formulas:	
Rigid-body analysis: $\mathbf{v}_B = \mathbf{v}_A + \boldsymbol{\omega} \times \mathbf{r}_{B/A}$ $\mathbf{a}_B = \mathbf{a}_A + \boldsymbol{\alpha} \times \mathbf{r}_{B/A} - \omega^2 \mathbf{r}_{B/A}$ Relative motion: $\mathbf{v}_B = \mathbf{v}_A + \boldsymbol{\Omega} \times \mathbf{r}_{B/A} + (\mathbf{v}_{B/A})_{xyz}$ $\mathbf{a}_B = \mathbf{a}_A + \dot{\boldsymbol{\Omega}} \times \mathbf{r}_{B/A} + \boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{r}_{B/A}) + 2\boldsymbol{\Omega} \times (\mathbf{v}_{B/A})_{xyz} + (\mathbf{a}_{B/A})_{xyz}$	
Moment of Inertia Formulas:	
General Formula $I = \int_m r^2\, dm$	Parallel-axis theorem $I = I_G + md^2$

Center of Gravity and Mass Moment of Inertia of Homogeneous Solids



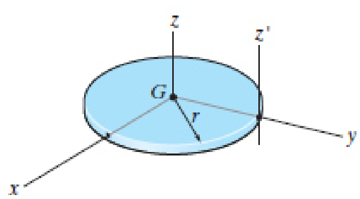
Sphere

$$I_{xx}=I_{yy}=I_{zz}=\frac{2}{5}mr^2$$



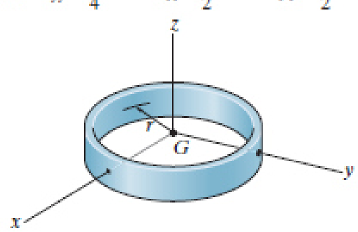
Hemisphere

$$I_{xx}=I_{yy}=0.259\,mr^2 \quad I_{zz}=\frac{2}{5}mr^2$$



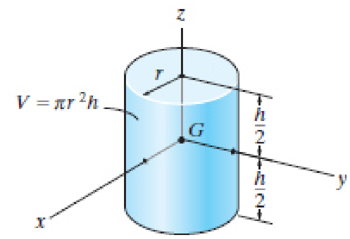
Thin Circular disk

$$I_{xx}=I_{yy}=\frac{1}{4}mr^2 \quad I_{zz}=\frac{1}{2}mr^2 \quad I_{z'z'}=\frac{3}{2}mr^2$$



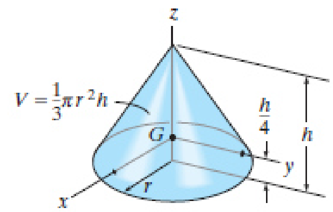
Thin ring

$$I_{xx}=I_{yy}=\frac{1}{2}mr^2 \quad I_{zz}=mr^2$$



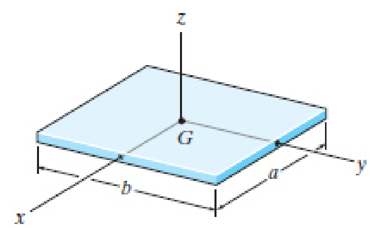
Cylinder

$$I_{xx}=I_{yy}=\frac{1}{12}m(3r^2+h^2) \quad I_{zz}=\frac{1}{2}mr^2$$



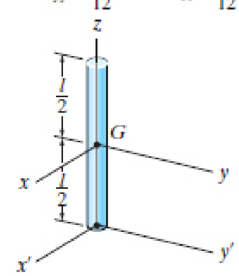
Cone

$$I_{xx}=I_{yy}=\frac{3}{80}m(4r^2+h^2) \quad I_{zz}=\frac{3}{10}mr^2$$



Thin plate

$$I_{xx}=\frac{1}{12}mb^2 \quad I_{yy}=\frac{1}{12}ma^2 \quad I_{zz}=\frac{1}{12}m(a^2+b^2)$$



Slender Rod

$$I_{xx}=I_{yy}=\frac{1}{12}ml^2 \quad I_{x'x'}=I_{y'y'}=\frac{1}{3}ml^2 \quad I_{z'z'}=0$$