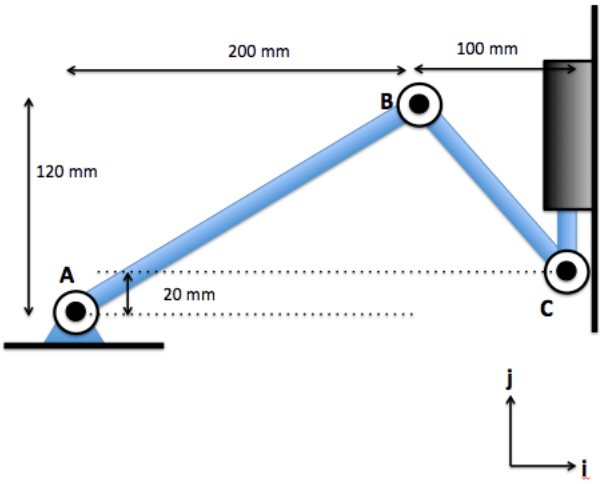
ENGN 0040: Dynamics and Vibrations, Spring 2015

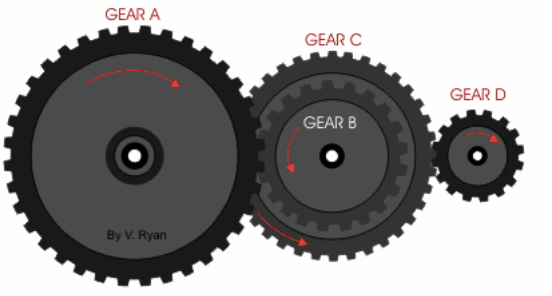
Homework 6: Rigid Body Kinematics
Due Friday April 17th

Problem 1: Consider the linkage system below. At the instance shown, point C moves downward at 1 m/s and has a downward acceleration of 3 m/s^2. Pay attention to the reference axis shown in the diagram, and be sure to denote the proper vector notation on all answers.



1.1. Write down the position vector of point B with respect to point A.
1.2. Write down the position vector of point C with respect to point B.
1.3 Write down the position vector of point C with respect to point A.
1.4. Write down a vector equation relationship between the linear velocity at point C and the linear velocity at point A. Using this equation, determine ω_{AB} and ω_{BC}, the rotational velocities of the two links. Be sure to properly denote the vector direction of the rotational velocity.
1.5. Write down a vector equation relationship between the linear acceleration at point C and the linear acceleration at point A. Using this equation, determine α_{AB} and α_{BC}, the rotational accelerations of the two links. Be sure to properly denote the vector directions.

Problem 2: In the figure below, gears B and C are a compound gear, meaning they are rigidly attached to one another. Instead of a gear radii, the gear ratio of the system can be calculated based on the number of teeth in each gear, given by the table below.

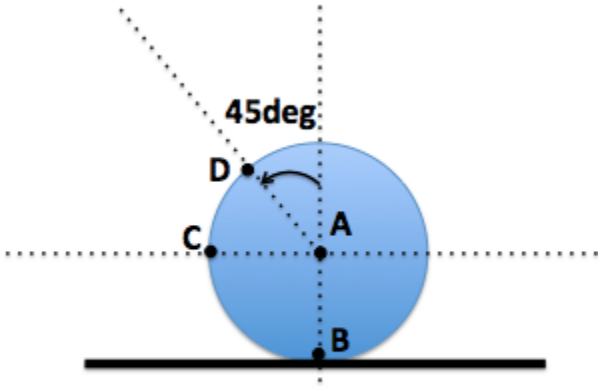


GEAR A	GEAR B	GEAR C	GEAR D
120 T	40 T	80 T	20 T

2.1. If gear A rotates clockwise at 30 rpm, what is the direction and angular velocity of gear D?
2.2. In 10 minutes time, how many complete rotations does each gear make?

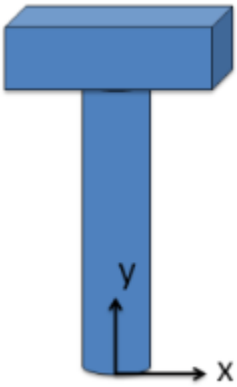
2.3. Now assume the gears are at rest at $t = 0$, and an angular acceleration of 5 m/s^2 in the clockwise direction is applied to gear D for 2 seconds. From 2 seconds to 8 seconds there is no angular acceleration applied. Then from 8 seconds to 10 seconds there is a counterclockwise angular acceleration of 5 m/s^2 applied to gear D. How many revolutions does gear D undergo during the 10 second period? How many revolutions does gear A undergo during the 10 second period?

Problem 3: The disk (R=0.5 m) rolls without slipping on the plane surface. The velocity of point A is 6 m/s to the right, and the acceleration of A is 20 m/s^2 to the right.



3.1. What is the angular acceleration vector of the disk?
3.2. Determine the accelerations of points B, C, and D.

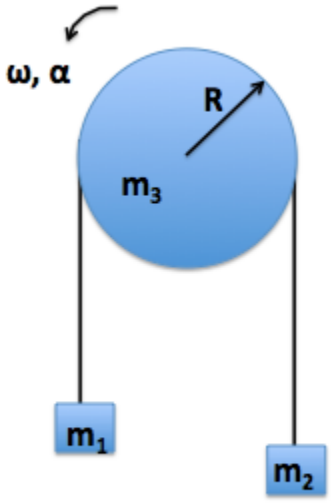
Problem 4: A cylinder of length L and radius R is welded to a rectangular prism of length B and cross section $A \times A$. The density, ρ, of the two bodies is the same and uniform.



4.1. Determine the mass moment of interia about the x-axis.

4.2. Determine the mass moment of interia about the y-axis.

Problem 5: Consider the pulley system below where $m_1 = 10kg$, $m_2 = 8kg$, and $m_3 = m_{pulley} = 4kg$.



5.1. In terms of R, g, ω and α, what is the acceleration of mass 2?

5.2. What is the acceleration of mass 2 of a massless pulley? Which has the greater angular acceleration (with mass or massless) and why?