2.007 Design and Manufacturing I
Spring 2009

2.007 Design and Manufacturing 1

Homework #2 Servomotors, Mechanisms & CAD

*NAME:*_____

Date Issued: Tuesday 24 FEB, 11AM
Date Due: Thursday 5 MAR, 11AM

Please answer the following 4 questions showing your work to the extent possible within the allotted time. This assignment should not take more than 6 hours.

Point allocations are listed for each question. The points sum to 100.

As described in the course policies document, this is one of four homeworks you will complete in this course. Each homework counts as 5% of your total grade. You will submit your work at lecture by hardcopy or via the course web site.

1) (25 total) You're building a small, electric-powered vehicle to climb up a 20 degree ramp (similar slope as the ramp into the contest starting box). The vehicle will be operated by two servomotors that can continuously rotate the output shafts that attach directly to wheels on the left and right sides of the vehicle. The manufacturer's specifications indicate each servo is capable of a no load speed of 50 rpm and a stall torque of 0.3 N*m (similar to the specs of the HS-311 standard servos in the kit). The total vehicle weight along with its payload is 12 N (a little more than the weight of a liter of water). All the wheels have a radius of 6cm. The front and rear axles are 20cm apart. The center of gravity of the vehicle and payload is halfway between the front and rear wheels and is 3cm above the surface on which the vehicle runs.

A) (5 points) Make a free body diagram of the vehicle driving up a 20 degree ramp after having reached its steady-state velocity. Label each force. Write three equations of equilibrium.

B) (5 points) Estimate the steady-state velocity of the vehicle. Sketch the torque-speed curve and power-speed curve of the servos and indicate on these curves the shaft speed attained when climbing steadily up the 20 degree ramp.

C) (5 points) Estimate the smallest coefficient of friction needed between the wheels and the ramp for which the vehicle will avoid slipping between the wheels and the ramp when climbing steadily up the 20 degree ramp.

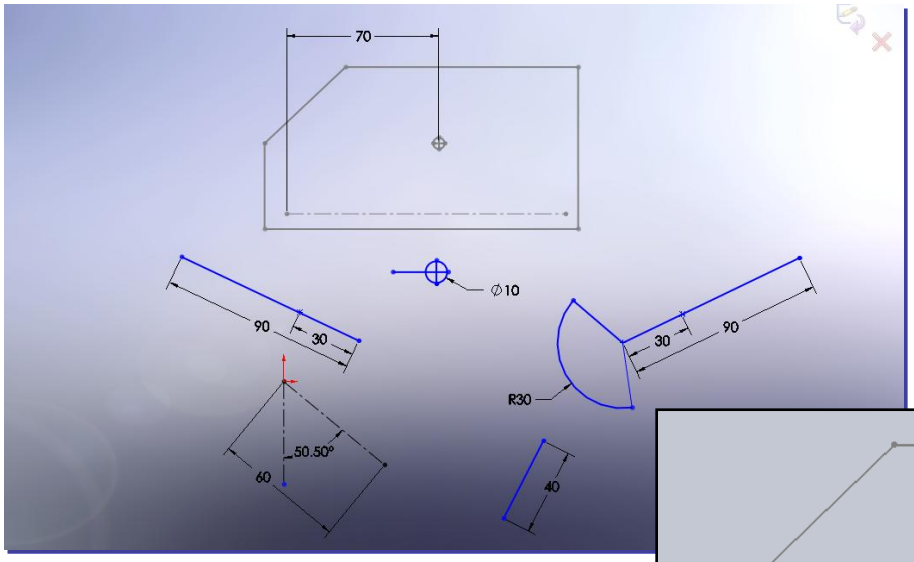
D) (5 points) Is the smallest coefficient of friction attained (from part C) in a front wheel drive configuration or a rear wheel drive configuration? Explain with a few sentences and/or sketches.

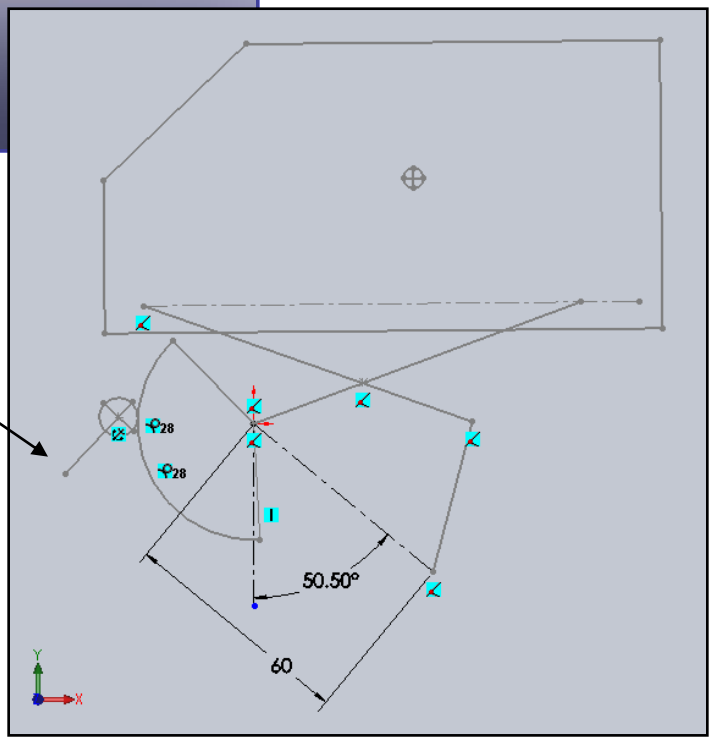
E) (5 points) Estimate the largest angle at which the vehicle will be able to proceed up the ramp very slowly, but without stalling. Check that the center of gravity is placed so that tipping dies not occur before stall.

2) (25 total) Consider the window glass mechanism shown in the two figures below. The figure on the left shows shows the mechanism's pin locations and its disassembled links, and can be found on the course website in a file named "window08.sldprt". The figure on the right shows the assembled components (you'll have to make this yourself).

A) (10 points) Make a 2D sketch in SolidWorks of the window glass mechanism, i.e. assemble the links. Once you have a sketch that moves properly, you will find it useful to apply a virtual work principle to attack part B.

B) (15 points) Estimate the magnitide of a force applied perpenducular to the handle (labeled below) that would be just sufficient to keep the window glass from falling. You can assume: 1) the mechanism is in the position shown in the figure below; 2) there is negligable friction in the joints; and 3) the window glass has a mass of 1kg and that the mass of the links and gears is small by comparison.



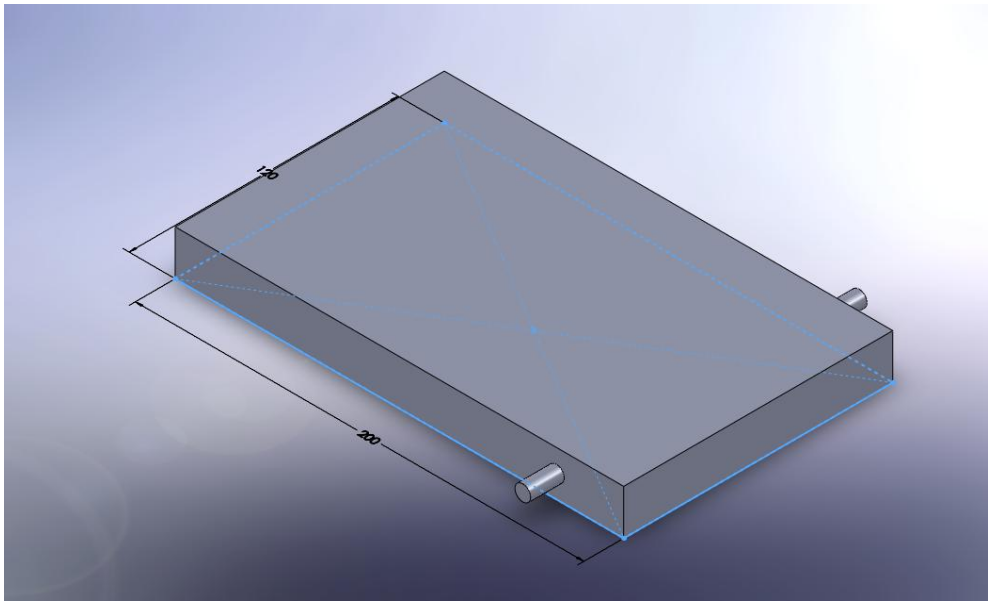


Handle

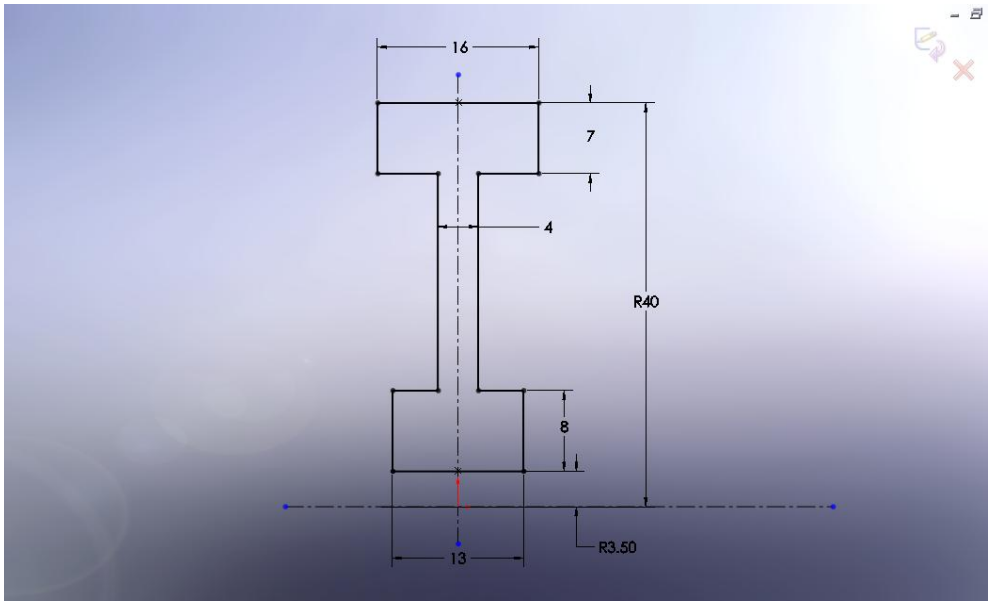
NOTE: Cars actually used to require manual cranking to raise and lower the windows!

3) (25 points total) You are to create parametric solid models of components for a simple car.

A) (10 points) Create a chassis for the car, consisting of a simple rectangular extrude feature, 200 mm x 120 mm x 20 mm. There should be two axles, consisting of simple circular extrude features. The axles should be 7mm in diameter, 15 mm in length, centered vertically on the side of the chassis, and located 70 mm from the center of the chassis, as shown in the figure below.



B) (15 points) Create a wheel for the car, consisting of a single revolved feature with the dimensioned cross-section shown in the figure below.



4) (25 points total) Create an assembly model of the car, consisting of the chassis and two wheels.

A) (20 points) For each axle/wheel pair, use 1 **concentric mate** and 1 **coincident mate.** Generate a single figure (using **View/Screen Capture/Image Capture**) showing the result.

B) (5 points) Examine the assembly carefully for any interferences. If you find an interference, make a change to a single dimension to eliminate it. Generate a single figure (using **View/Screen Capture/Image Capture**) showing the result.