Your Name: ______________________________

Your TA name: ______________________________

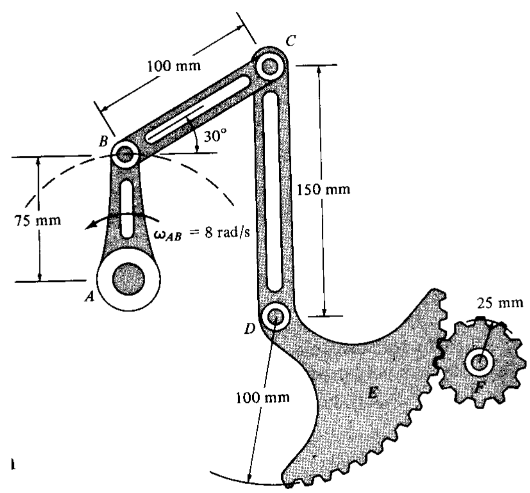
Section day: ______________________________

MAE325, Homework 5

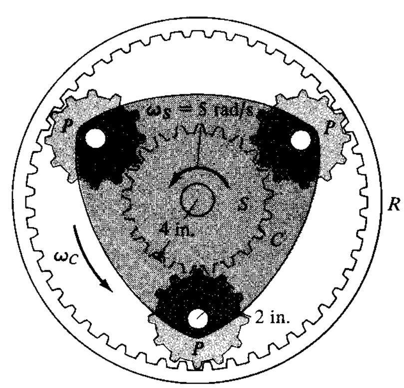
(Due Wednesday, September 29, 1999, 9:04 AM)

Please follow the homework directions from the course WWW pages, the directions of the first homework, and the advice marked on your previously graded homework.

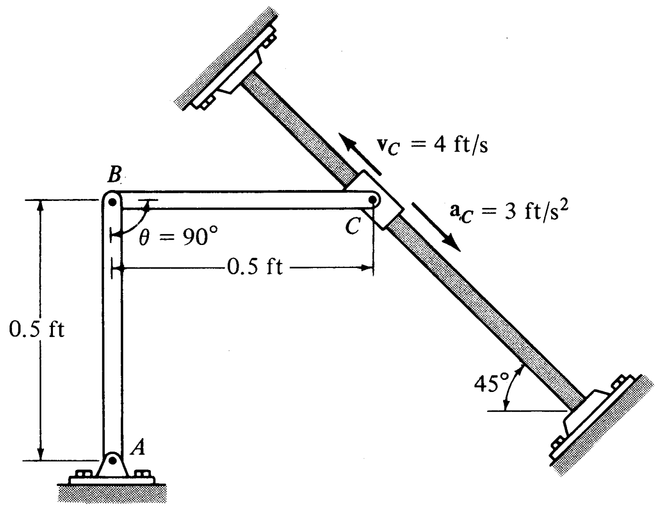
1. The rotation of link AB creates an oscillating movement of gear F. If AB has an angular velocity of $\omega_{AB} = 8$rad/s, determine the angular velocity of gear F at the instant shown. Gear E is a part of arm CD and pinned at D to a fixed point.



2. Part of an automatic transmission consists of a planetary gear system with a fixed ring gear R, three equal planet gears P,the sun gear S, and the planet carrier C, which is shaded. If the sun gear is rotating at $\omega_S = 5$rad/s, determine the angular velocity of the planet carrier. Note that C is pin-connected to the center of each of the planet gears. (See Ruina/Pratap page 501 and 504-5. Also Norton pg 723-25.)



3. Determine the angular acceleration of link BC at the instant $\theta = 90^o$ if the collar C has an instantaneous velocity of $v_C = 4\text{ft/s}$ and deceleration of $a_C = 3\text{ft/s}^2$ as shown.



4. This problem extends the bicycle pedaling problem from last week. It should take 3-5 hours to do. If you are tired of bicycles and have another mechanical gadget that interests you even more than a bicycle, and that gadget includes a 4 bar linkage, you may set up an equal-content problem with that system to replace this assigned problem.

   Repeating the problem description (with a few minor changes): Consider a bicycle rider's leg as part of a planar 4 bar linkage consisting of the thigh (upper leg), shank (calf or lower leg), crank, and the bike frame up to the riders seat. This model neglects the flex of the ankle which we think of as locked. The four hinges in this 4-bar linkage are the hip joint, the knee joint, the pedal bearing and the crank axle. For simplicity assume that the hip is 29 (not 30) inches directly above the crank and that at the start of motion the crank is horizontal with the pedal axle 8 inches in front of the crank. The shank is 20 inches long and the thigh is 18 inches long. Assume the crank is rotating at a constant 60 revolutions per minute and the rider is going to the right. The bike is going at constant speed. Assume the torques at the thigh and knee are zero (no muscle contraction). *Include* gravity. Assume the thigh has a uniformly distributed mass of 30 lbm and the shank a uniformly distributed mass of 15 lbm and the crank has negligible mass.

   - Make a well labeled plot of the torque supplied to the crank by one leg, as a function of time for one revolution, starting with the pedal directly forward of the crank. [Check: the net area under this curve is zero]. If you do not get that far, clearly present plots of intermediate results that you did find (angles, or angular rates).
   - Extra credit: make an animation of the pedaling leg. Document your animation with some snap shots.

   To do this problem you should first calculate segment angles using, say, ODE23 as in lecture (although there are other ways). Then you should calculate segment angular accelerations at each time by setting up and solving a set of linear equations that come from the looking the acceleration of a point on the linkage two different ways. You should then draw free body diagrams of the 4-bar linkage segments and set up the equations of dynamics. These will be 9 equations in 9 unknowns (all motion is known at this point, its just a matter of calculating forces and the crank moment). Solve these equations at each time step and then plot the resulting crank moment as a function of time.

   What does this problem have to do with real bicycling? In this calculation you have calculated the torque on the pedal as a function of angle assuming no muscle use. Thus you will find a curve whose integral is zero (the net work of the foot on the pedal is zero if there is no muscle usage since the net work of gravity is zero and there is no change of system kinetic energy). What you are calculating is the contribution to the crank torque from gravity and inertail terms. To this is added (though not in your calculation here) the torque due to the muscle contractions. In other words, the torque on a bicycle crank differs from that due to muscle contraction by an amount you calculate here.