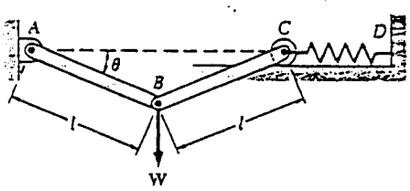
1. (20%) Describe the meanings or give the definitions of the following terminologies. Note that if you use any mathematical symbols to describe or define a terminology, you must also describe or define the symbols.

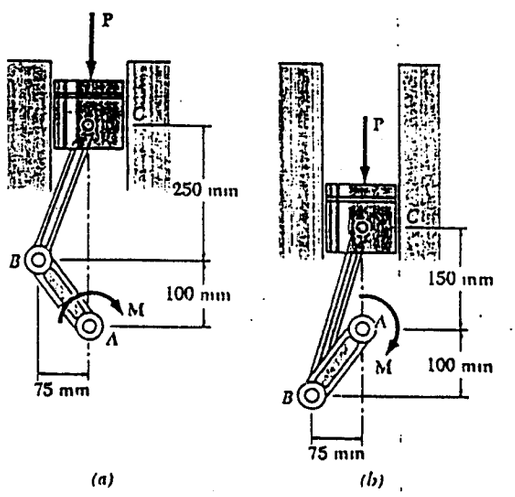
   a. *Newton's Three Fundamental Laws*
   b. *Rigid Bodies*
   c. *Coefficient of Static Friction & Coefficient of Kinetic Friction*
   d. *Moment of Inertia of an Area*
   e. *Principle of Virtual Work*

2. (10%) A vertical load W is applied to the linkage at B. The constant of the spring is k, and the spring is unstretched when AB and BC are horizontal. Neglecting the weight of the linkage, show that when the linkage is in equilibrium, the following relation among θ, W, l, k must be satisfied:

$$(1-\cos\theta)\tan\theta = \frac{W}{4kl}$$



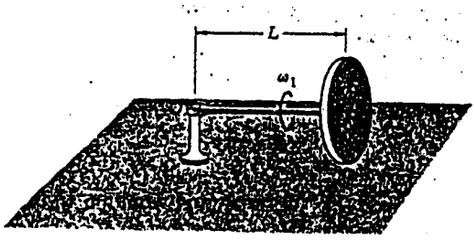
3. (10%) A force P of magnitude 2.4 kN is applied to the piston of the engine system shown. For each of the two positions shown, determine the magnitude of the couple M required to hold the system in equilibrium.



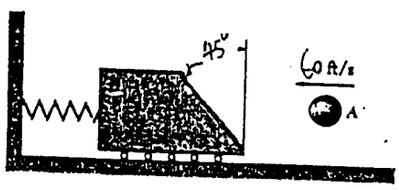
4. A homogeneous disk of radius r and mass m is mounted on an axle OG of length L and negligible mass. The axle is pivoted at the fixed point O and the disk is constrained to roll on a horizontal floor. Knowing that the disk rotates counterclockwise at the constant rate w1 about the axle, determine (a) the force (assumed vertical) exerted by the floor on the disk, (b) the reaction at the pivot O. (20%)

5. The position of the stylus tip A is controlled by the robot shown. In the position shown the stylus moves at a constant speed u = 200 mm/s relative to the solenoid BC. At the same time, arm CD rotates at the constant rate w2 = 2.5 rad/s with respect to component DEG. Knowing that the entire robot rotates about the X axis at the constant rate w1 = 1.5 rad/s, determine (a) the velocity of A, (b) the acceleration of A. (20%)

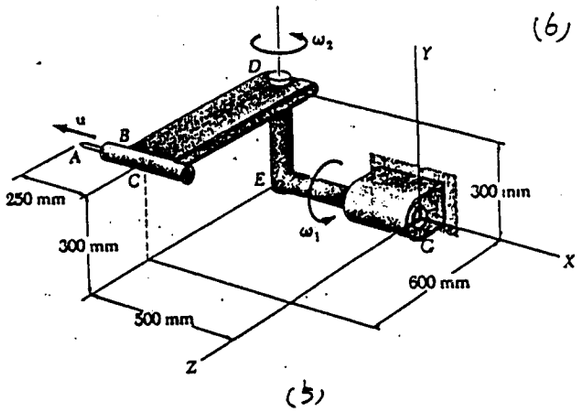
6. A 2 -lb sphere A is moving to the left with a velocity of 60 ft/s when it strikes the inclined surface of a 5-lb block B which is at rest. The block is supported by rollers and is attached to a spring of constant k =15 lb/in. Knowing that the coefficient of restitution between the sphere and the block is e = 0.8 and neglecting friction, determine the maximum deflection of the spring. (20%)



(4)



(6)



(5)