THE ASSOCIATION OF PROFESSIONAL ENGINEERS

98-MEC-B1 ADVANCED MACHINE DESIGN

NATIONAL COURSE EXAMINATION

May 2003 **TIME ALLOWED: 3:00 (three) Hours**

Please Note:

- *Answer QUESTION NUMBER-1, and only TWO questions from PART-II of the examination.*
- *Make your answer neat, write your equations in symbol form first and put intermediate and final results in boxes.*
- *Examination is open book (one book only). Students may use only one textbook of their choice plus their own notes.*
- *Any non-communicating calculator is permitted.*
- *State all assumptions clearly. If doubt exists as to the interpretation of any question, submit with the answer paper a clear statement of any assumptions or interpretation made.*
- *Assume any missing data and make sure to properly state it in your answer.*
- *Make sure your name and student number (if applicable) is written on the answer book and any other attachments.*
- *Total points of the examination are 100 marks.*

PART- I: ONLY QUESTION-1 – MUST BE SOLVED

QUESTION-1: DESIGN OF A HOISTING MECHANISM (50 points)

Figure-1 shows a sketch of a vehicle-lifting platform powered by two identical hydraulic cylinders that are pinned to two identical beams ABC (one on each side). The four lifting beams, two ABC and two DE are pinned to the two side beams GH at C and E and pinned to the ground at A and D, respectively. The range of the angle θ is 20° to 85° with other dimensions shown in figure. For the design purpose, consider a typical vehicle with weight = 30 KN and a wheel base (distance between the centers of the wheels) L_{wb} = 3 m. Assume that the vehicle's center of gravity is closer to the front axis and divides the wheel base distance with a ratio of 2:1. It is required to:

- Draw a free body diagram to beams ABC, DE and GH and to find an expression for the cylinder force in terms of vehicle weight, the angle θ, and the length L.
- Determine the appropriate location of point F assuming that the cylinder can expand up to 1.7 times its shortest length.
- Determine the diameter of the piston rod and the cylinder wall thickness. Use a factor of safety of 2.25.
- Determine the cross section dimensions of beam ABC. Assume a solid rectangular cross section with 50 mm thickness and use a factor of safety of 2.25 and consider any appropriate stress concentration factors.
- Provide a free-hand engineering drawing to joint C assuming that beam GH has an I cross section (you may use a straight edge).

The following data is assumed:
Piston rod material AISI 1040 steel (Annealed)
Cylinder material AISI 1030 steel (Annealed)
Inside diameter of cylinder 90 mm
Material of all beams ASTM-A36 steel
All factors of safety = 2.0 (if not specified)
Neglect weights of hoist and all other members.
Make reasonable assumptions whenever needed, but make sure that they are necessary and make clear note of them in your answer.

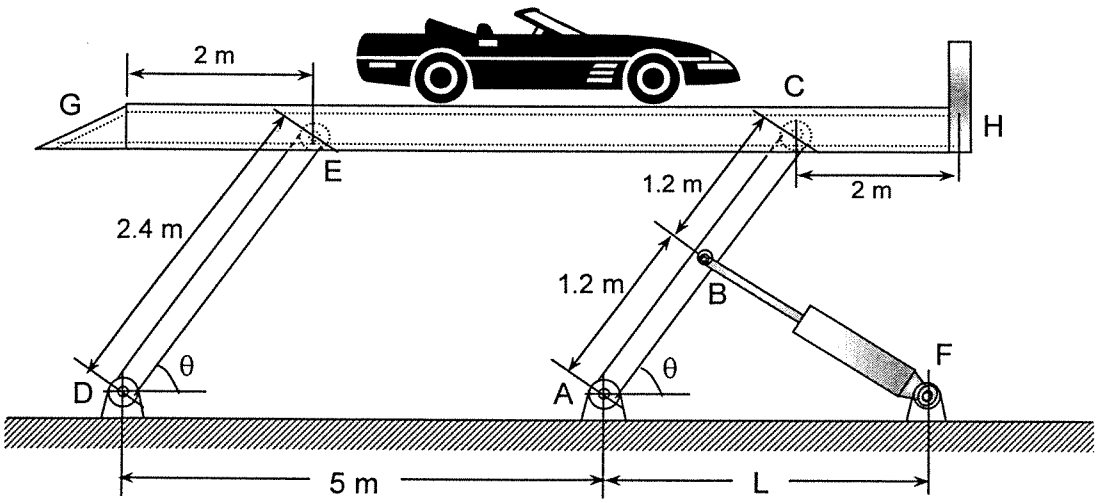

Figure-1

PART- II: QUESTIONS 2, 3 AND 4 - ONLY SOLVE TWO QUESTION FROM THIS PART

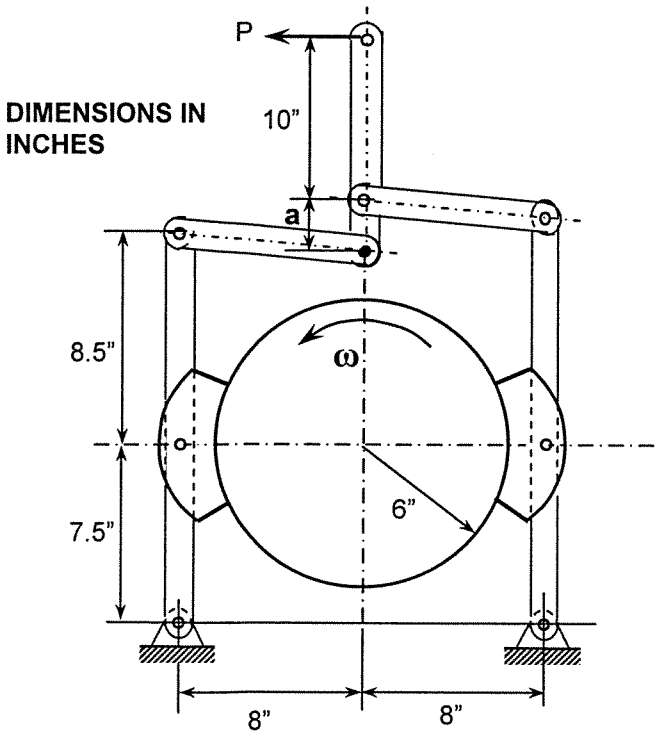

Figure (2a)

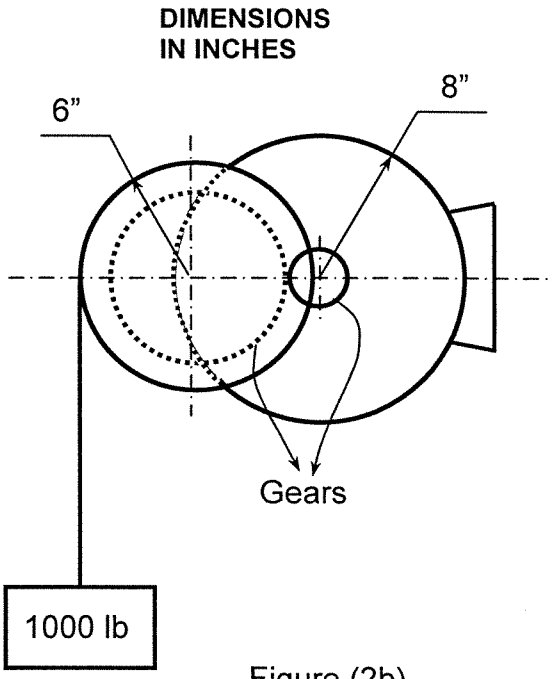

Figure (2b)

QUESTION-2: Brake Design **(25 points)**

(a) Figure (2a) shows a brake that has two short shoes with coefficient of friction of 0.3. Find the value of the distance 'a' that will cause the wear to be the same for both shoes.

(b) Figure (2b) shows a block brake with one short shoe that is to be designed for a (pV value of 55,000 where p is the average pressure in psi and V is the velocity in foot per minute). The coefficient of friction is 0.2, the area of the shoe is 18 in^2, and the diameter of the brake drum is 16 inches. A cable drum 12 inch in diameter is connected to the brake drum by means of gearing. The brake drum rotated three times as fast as the cable drum. Find the uniform velocity at which the 1000-lb weight at the end of the cable is being lowered and find the value of the average shoe pressure.

QUESTION-3: **(25 points)**

Figure-3 shows a sketch of a scotch yoke. The disc is rotating with a constant angular velocity ω causing the piston rod to move with a simple harmonic motion. The piston rod has a circular cross section with 1.0 inch diameter and is supported by two bearings at E and F. The masses of the piston head, piston rod and disc are m_h, m_r, and m_d, respectively. At the position shown, the piston head is subjected to a restoring force of *100 lb* in the negative *x-direction* and a

negligible reaction in the *y-direction*. All joints in the system are assumed frictionless. Find the acceleration of the piston and find the reactions at the bearings E, F and A, and the force exerted at the sliding joint C. Draw a free body diagram for the piston rod with the piston head showing all forces.

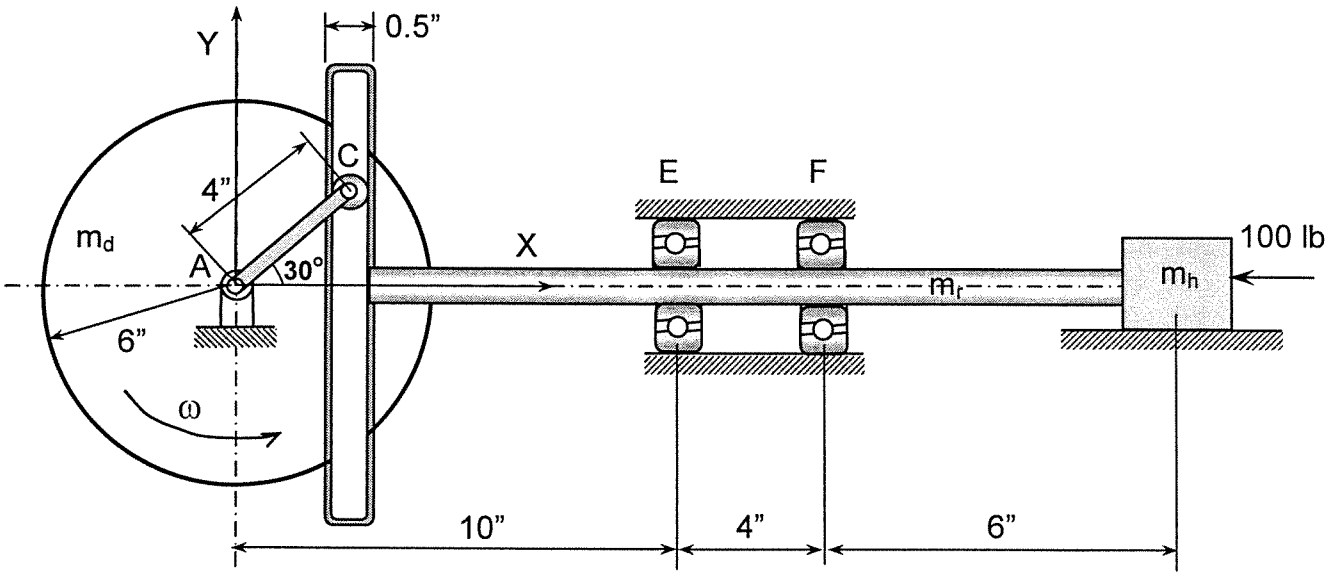

Figure-3

QUESTION-4: DESIGN OF JOURNAL BEARING **(25 points)**

A journal bearing of length L=1.0 inch, diameter D=2.0 inches, and a diametral clearance of 0.002 inch supports a 400 lb load while rotating at 1800 rpm. SAE-10 oil is used with an average film temperature of 130 $^{\circ}$F. Determine:

a) The minimum oil film thickness, coefficient of friction and the maximum film pressure.
b) The angle between the load direction and each of point of minimum film thickness, point of termination of film and point of maximum film pressure.
c) Total circumferential and side or leakage oil flow rates.
d) If the cooling rate for the housing is 2 Btu / (hr ft^2 $^{\circ}$F). Take the housing area in cooling as 8 times the developed journal area and find the rise in housing temperature.