

THE ASSOCIATION OF PROFESSIONAL ENGINEERS
98-MEC-B1 ADVANCED MACHINE DESIGN
NATIONAL COURSE EXAMINATION

December 2004

TIME ALLOWED: 3:00 (three) Hours

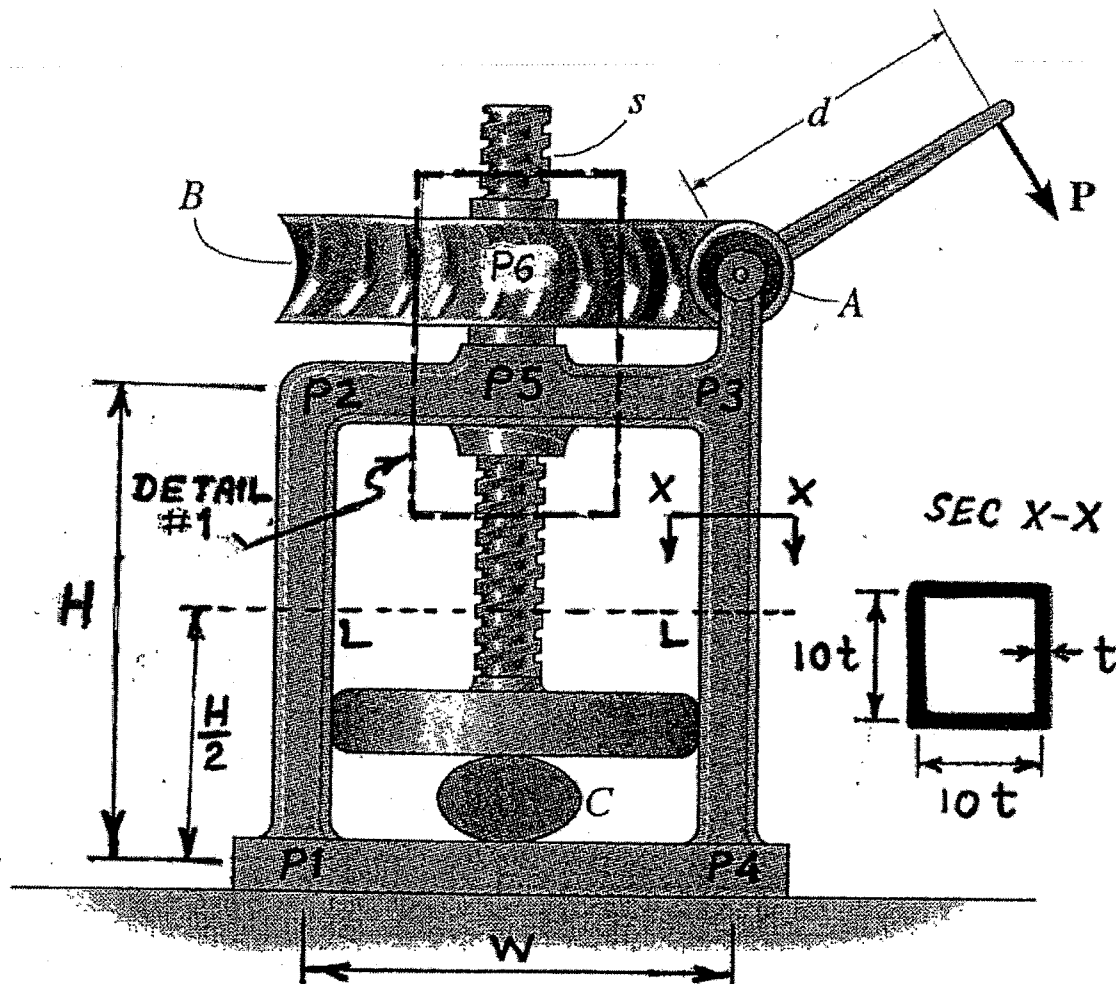
Please Note:

- ◆ 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 HAND PRESS

(50 points)



The figure shows a schematic of a hand press used for small pressing jobs. The press is operated by a worm gear at *A* that turns a horizontal gear-*B*. It takes *n* turns of the worm to produce one turn of the gear-*B*. The load is assumed to be applied perpendicular to the arm as shown in figure at a distance *d*. The power screw *s* has a lead equal to *l*. The cross section of the press body is a hollow thin-walled square box section with uniform thickness *t* and sides $10t$. The following data is given:

- Maximum exerted load $P = 150 \text{ lb}$
- Arm effective length, $d = 20 \text{ in}$
- Frame height (distance from *P1* to *P2*), $H = 60 \text{ in}$
- Frame width (distance from *P1* to *P4*), $W = 30 \text{ in}$
- Factor of safety for all calculations = 2.25

It is required to:

- a) Find the maximum load that may be exerted by the press in terms of the hand applied load P .
- b) Assume that the maximum interference between the press head and the vertical sides occur at level $L-L$ (half way along the height). Calculate the maximum lateral deflection of the frame in terms of variables P, H, W, E (*Young's modulus of the material*), I (*moment of inertia of cross section*). Assume that the bed (along $P1-P4$) is completely fixed to ground and that the vertical sides are rigidly fixed to the bed and to the top horizontal member ($P2-P3$).
- c) Find the internal forces on a section at level $L-L$.
- d) Choose an appropriate material to fabricate the frame of the press and find the minimum thickness of the section based on the internal forces obtained in part-c above.
- e) Provide an appropriate engineering drawing to show details of the area marked Detail #1 on the figure. Just show a sectional view of the assembly. Make sure to consider appropriate lubrication facility and maintenance due to wear in your design. Detailed connections at points P5 and P6 should be clear in the sectional view. No calculation is required. You may use a straight edge in your drawing.

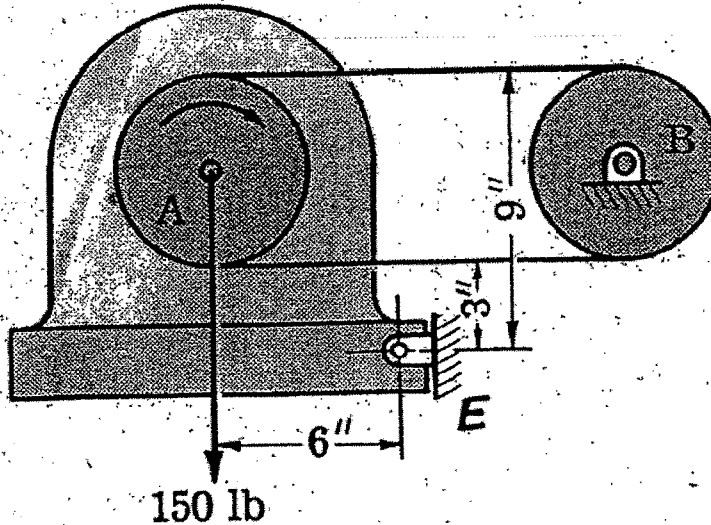
Hints:

1. Ignore horizontal reactions at points P1 and P4.
2. For the power screw, use a value of 0.25 inch for both the pitch and the lead and a diameter of 2.0 inch.

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

QUESTION-2: Belt Design

(25 points)



A pivoted motor drive (as shown in figure) has several advantages over a fixed center drive. One of the advantages is that the stretch in the belt is automatically taken care of by the effect of the weight of the motor. Another claimed advantage is the reduction of bearing loads for operation at partial load. The following data is given:

	<u>Pulley-A</u>	<u>Pulley-B</u>
Diameter	6 in	6 in
Coefficient of friction	0.4	0.5
Angle of wrap	180°	180°

The belt has a speed of 3000 ft/min , a width of 4.0 in , thickness of 0.125 in and weighs 0.04 lb/in^3 . The motor weighs 150 lb .

- Find the total force that has to be carried out by the bearings in case of full power or full load capacity operation (i.e., find tensions T_1 and T_2 in the belt for maximum capacity).
- Find the total force that has to be carried out by the bearings in case of 50% of the full load capacity. Assume that for 50% capacity, we have

$$(T_1 - T_2)_{50\% \text{ capacity}} = 0.5(T_1 - T_2)_{100\% \text{ capacity}}$$
- Find the maximum force that has to be carried out by the pin at E. Choose an appropriate material and find the minimum diameter of the pin.

QUESTION-3: Brake Design

(25 points)

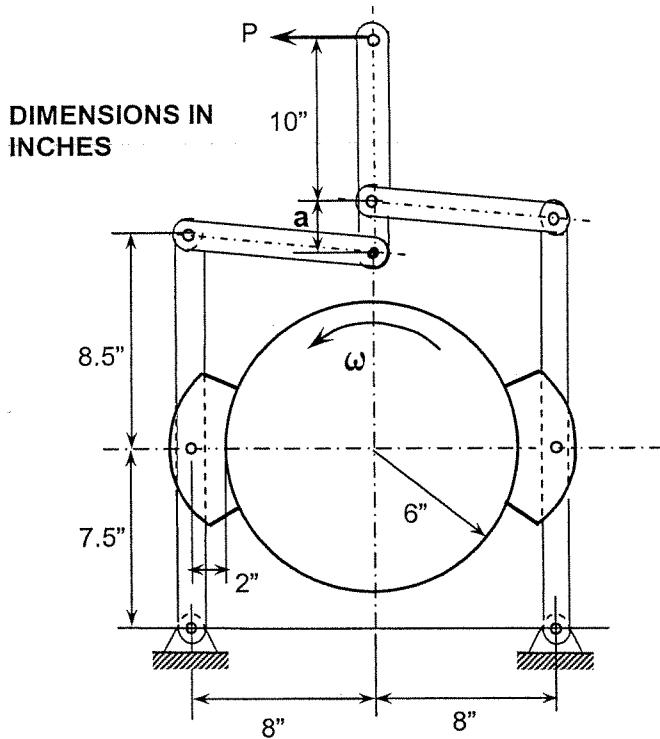


Figure (3a)

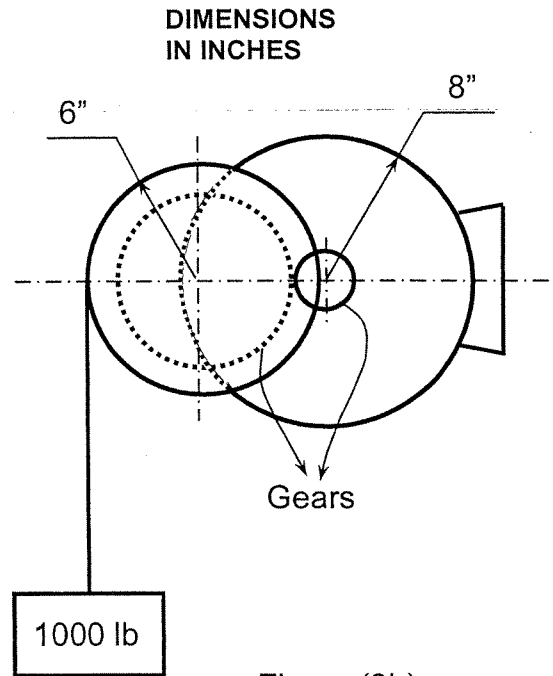
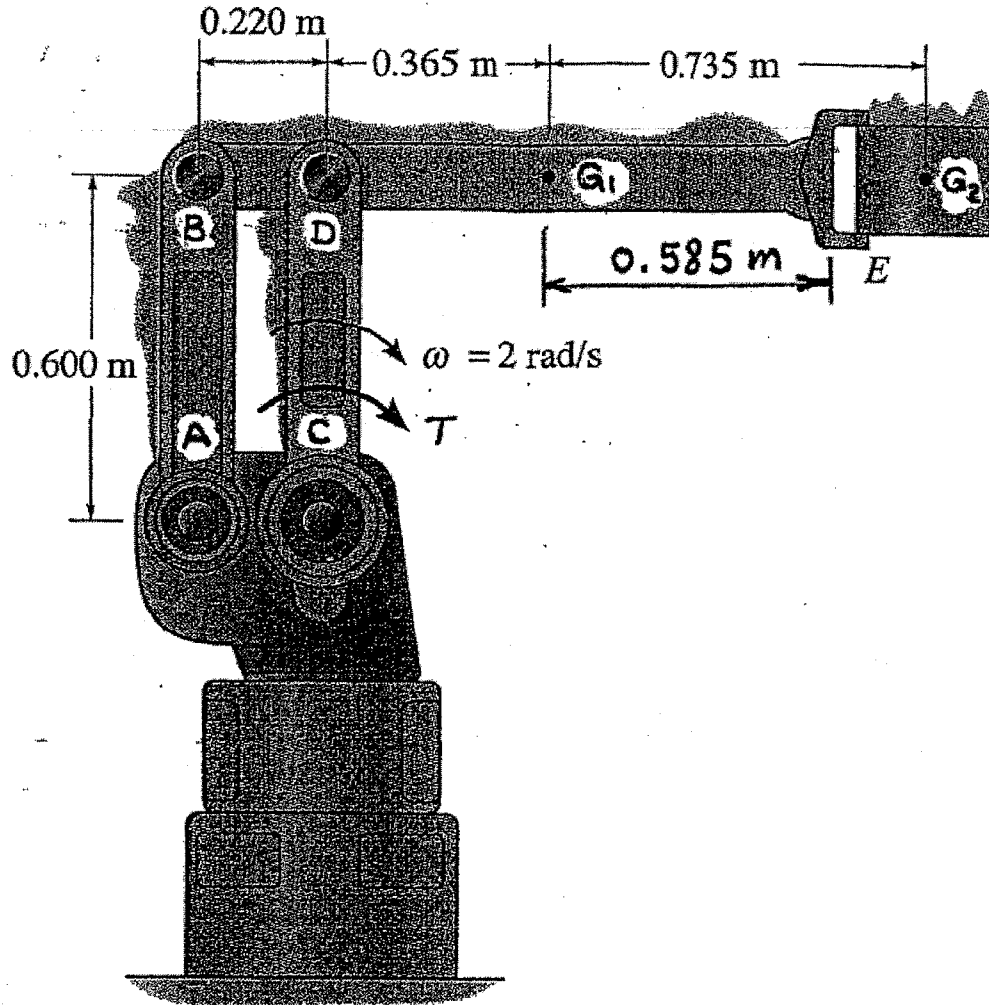


Figure (3b)

- (a) Figure (3a) 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 (3b) 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-4: DESIGN WITH DYNAMIC LOADS**(25 points)**

The robot arm BDE shown in the figure is activated by applying a torque T to link CD . Link BDE has a mass of 15 kg acting at G_1 and is carrying a load of 50 kg at G_2 . Links AB and CD have masses of 10 kg each acting at their CG (these are uniform links with CG at the middle point). The mass moment of inertia of all links about their CG is given by $mL^2/12$ where m is the mass of the link and L is its length. For the position shown, link CD is rotating clockwise with a uniform angular velocity of 2 rad/sec .

- i) Draw the velocity and the acceleration diagrams for the system and find the linear and angular accelerations of all links.
- ii) Find the inertia forces and inertia torques of all links.
- iii) Determine the required input torque to drive the mechanism in the given position.
- iv) Determine the pin forces at pins B and D and the maximum stress in link BDE assuming a solid square cross section with dimensions $b \times b$.