CARLETON UNIVERSITY

Final
EXAMINATION
April 2000

DURATION: 3 HOURS

No. of Students: **125**

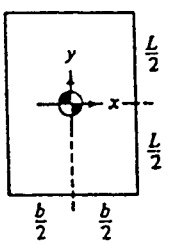
Department Name & Course Number: **Mechanical & Aerospace Engineering, 86.230B**
Instructor(s) S.A. Sjolander

AUTHORIZED MEMORANDA
1 sheet 8 1/2 x 11, both sides, calculator

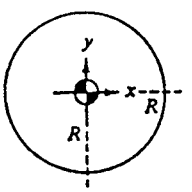
Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy immediately to a proctor. This question paper has **7** pages.
This examination question paper **MAY** be taken from the examination room.

ATTEMPT ALL QUESTIONS. THE VALUE OF EACH QUESTION IS GIVEN IN THE MARGIN. DRAW COMPLETE AND FULLY-LABELLED FREE-BODY DIAGRAMS OR CONTROL VOLUMES WHERE APPROPRIATE.

Geometric properties of common cross sections:



$A = bL$
$I_{xx} = \frac{bL^3}{12}$
$I_{xy} = 0$



$A = \pi R^2$
$I_{xx} = \frac{\pi R^4}{4}$
$I_{xy} = 0$

Miscellaneous data:

Air: $R = 287$ Nm/kgK
$C_p = 1005$ Nm/kgK
$C_v = 716$ Nm/kgK

Water: $\rho = 1000$ kg/m^3
$= 62.4$ lb$_m$/ft^3
$C_v = 4180$ Nm/kgK

$°R = °F + 460$ $°K = °C + 273$

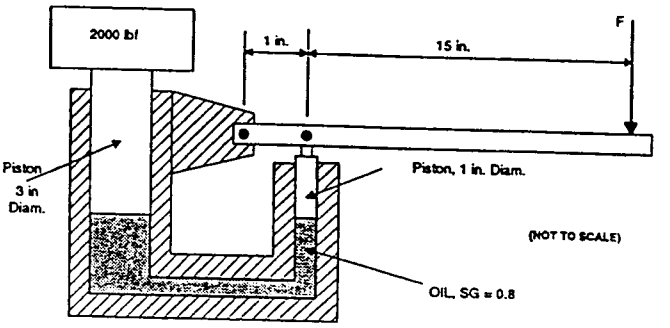
$g = 32.174$ ft/sec^2 $= 9.81$ m/s^2

1 HP = 550 ft-lb$_f$/sec $= 745$ Nm/s

See Page 7 for additional data.

1. (a) The drawing shows a simple hydraulic jack. The hydraulic oil has a specific gravity (SG) of 0.8. Neglecting the weight of the two pistons, what force F must be applied to the handle to support the 2000 lb_f weight? The lower surfaces of the two pistons are at the same elevation.

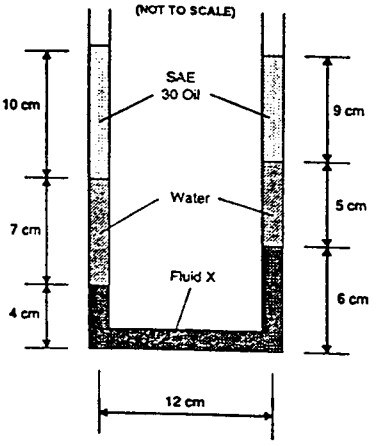
[8]



(b) What is the specific gravity of the unknown fluid X? The U-tube is open to the atmosphere (P_{atm} = 101 kPa) and the SAE 30 motor oil has a specific gravity of 0.85.

[12]

[20]



2. Air enters the double bend shown below through a pipe with a diameter of 10 cm. The mass flow rate of air is 1.526 kg/sec. At the inlet to the double bend, the temperature of the air is T = 27° C and the density $\rho = 2.85$ kg/m^3. The air leaves the double bend through a nozzle with a diameter of 6 cm. The outlet flow conditions of the air leaving the nozzle are P = +30kPa (g), and T = 10° C. The pressure gauge is used to measure the pressure at the inlet to the bend. Neglect any pressure variation between the location of the pressure gauge and the flanges. The double bend lies in a vertical plane.

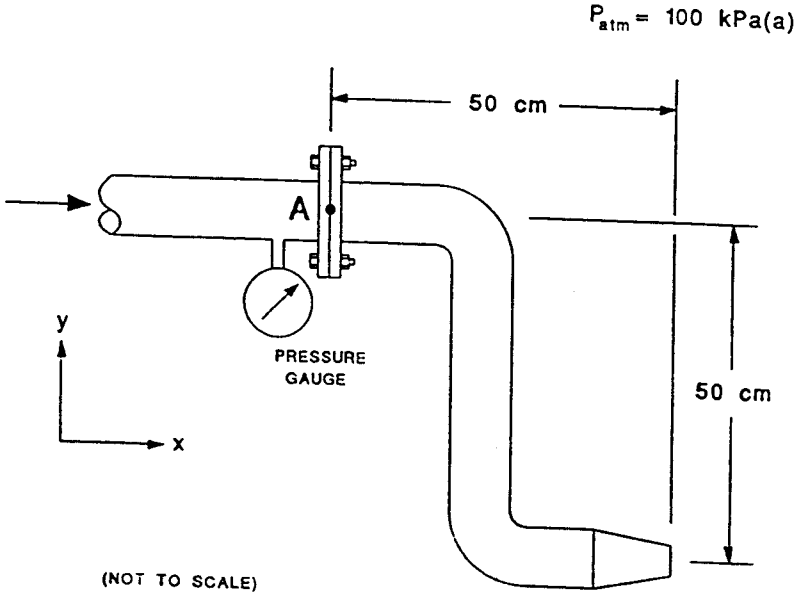
[5] a) Determine the absolute pressure which will be shown on the pressure gauge at the inlet to the bend for the conditions specified. Quote the result in kPa(a).

b) If the pressure at the inlet is 250 kPa(a) (**Note :** This is not necessarily the pressure that you should have obtained in part (a)), determine:

[8] i) The force in the flanged joint in the x direction. Indicate clearly whether the joint is in tension or compression.

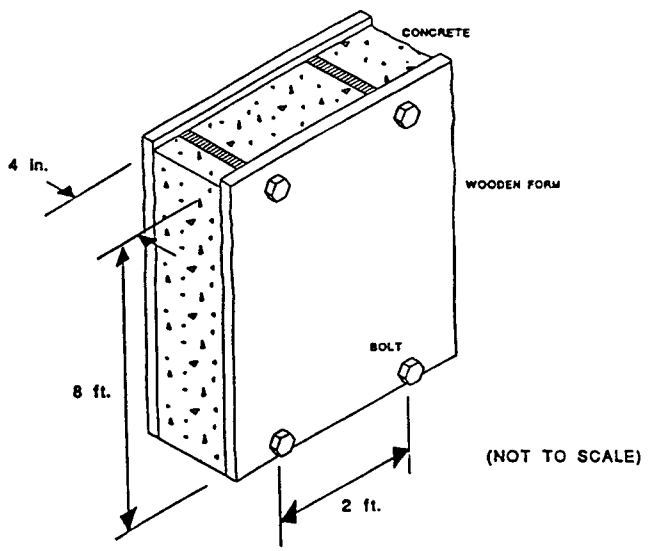
[7] ii) The moment about the z axis that must be applied at point A to prevent the bend from rotating. In your analysis, neglect the weight of the pipe itself.

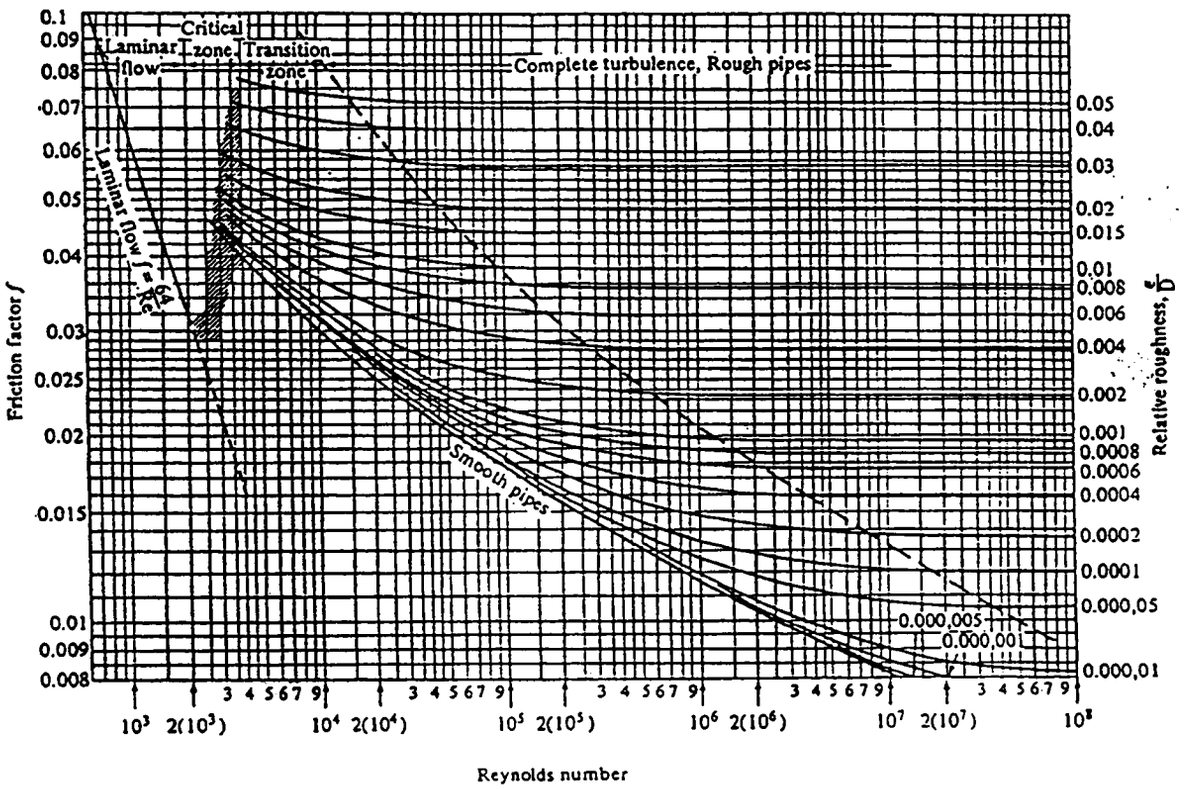
[20] ($R_{air} = 287$J/kg K, $\rho_{water} = 1000$ kg/m^3, g = 9.81 m/s^2)



3. When concrete is poured into forms, the forces on the forms can be estimated by assuming that the freshly poured concrete behaves as a liquid with a specific gravity of 2.4. The forms for a long concrete wall 4 inches thick and 8 feet high are held together by bolts spaced every 2 feet, as shown in the drawing. The bolts are right at the top and the bottom of the concrete. What is the force in each upper bolt? In each lower bolt? State clearly whether each bolt is in tension or compression.

[20]





$$f = \frac{h_f}{\frac{L}{D}\frac{V^2}{2g}} \qquad \textit{Reynolds Number} = \frac{VD}{\nu}$$