1. The bar has a mass of 10 kg and is subjected to a couple moment of $M=50$ Nm and a force of $P=80$ N, which is always applied perpendicular to the end of the bar. Also, the spring has an unstretched length of 0.5 m and remains in the vertical position due to the roller guide at B. Determine the total work done by all the forces acting on the bar when it has rotated downward from $\theta = 0°$ to $\theta = 90°$. (20 分)
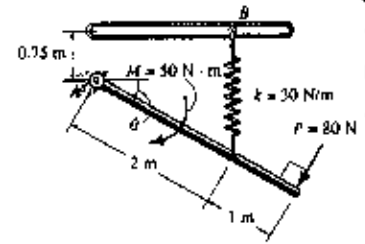
2. Determine the natural period of vibration of the pendulum. Consider the two rods to be slender, each having a weight of 8 lb/ft. (20 分)
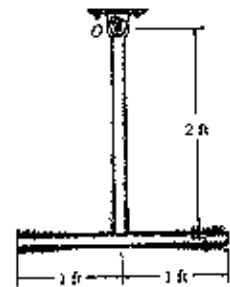
3. A strain gage has three wires oriented at $60°$ to one another, as shown in the figure. If $\varepsilon_0 = 220 \times 10^{-6}$, $\varepsilon_{60} = 120 \times 10^{-6}$, and $\varepsilon_{120} = -180 \times 10^{-6}$, determine the principal stresses and directions. The material under load is steel, for which $E=200$ GPa and $v = 0.3$. (20 分)
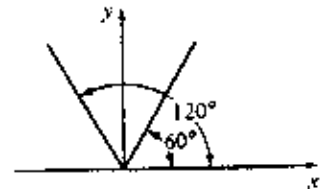
4. The rigid bar AB is supported by two vertical rods and is pinned at A. The yield point of the steel in the rods is 40 ksi , and they have the cross-sectional areas shown. Determine the ultimate load that may be applied at B. (20 分)
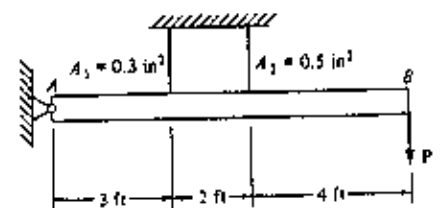
5. (a) 下表為不同進位之數字對照表，請於答案卷內重繪此表，並將空格填滿。 (12分)

Decimal	Binary	Octal	Hexadecimal
Base 10	Base 2	Base 8	Base 16
00			
01			
02			
03			
04			
05			
06			
07	0111		
08			
09			
10			
11			
12			
13		15	
14			
15			F

(b) 請作 $(2546)_8 \times (23)_8$ 一式之八進位乘法運算(以直式運算較方便)。 (8分)

6. 用 C/C++ (或 FORTRAN, MATLAB 均可)語言寫一程式，計算下列級數前 n 項之和，並印出其結果。還未算到第 n 項前，如遇到某項之值等於或小於 10^{-6} 時即可停止(計算至該項)，n 值由程式使用者輸入。 (20 分)

$$\frac{1}{1!} + \frac{2}{3!} + \frac{3}{5!} + \frac{4}{7!} + \cdots\cdots$$

7. Osbone Reynolds studied the flow behavior in a pipe. He found that one could examine the behavior of the flow by the dimensionless Reynolds number.
   (a) Define the Reynolds number for this problem. Give the physical interpretation of it. (5 分)
   (b) Describe the flow nature of the pipe flow based on the Reynolds number. (5 分)
   (c) Consider the flow situation near the inlet of the pipe. How does the flow velocity evolve along the pipe? Roughly draw a plot to explain. Also describe the pressure variation along the pipe axis.(8 分)

8. Fluid flows over a flat plate with a laminar boundary layer formed in which the stream wise velocity can be approximated by

$$\frac{u}{U_\infty} = a + b\left(\frac{y}{\delta}\right) + c\left(\frac{y}{\delta}\right)^2,$$

where a, b and c are constants, U_∞ is the free stream velocity, δ is the boundary layer thickness and y denotes the vertical distance from the plate. Assume the flow is two dimensional, incompressible and no pressure gradient in the stream wise direction.
   (a) List appropriate boundary conditions and solve a, b and c. (5 分)
   (b) Find the displacement thickness δ^* in terms of δ. (5 分)
   (c) What is the physical meaning of the displacement thickness? (5 分)
   (d) Consider a streamline enters the boundary layer 1 centimeter above the plate. How far from the plate the streamline will be at the location where $\delta = 3$ centimeters? (7 分)

9. Explain the following terms: (12分)
   (a) The Joule-Thomson coefficient,
   (b) Compressibility factor,
   (c) Enthalpy of formation,
   (d) Reversible process,

For problems 10 and 11, please define the system or control volume clearly, and list all assumptions used.

10. A rigid tank containing 0.4 m³ of air at 400 kPa and 30°C connected by a valve to a piston-cylinder device with zero clearance. The mass of the piston is such that a pressure of 200 kPa is required to raise the piston. The valve is now opened slightly, and air is allowed to flow into the cylinder until the pressure in the tank drops to 200 kPa. During this process, heat is exchanged with the surroundings such that the entire are remains at 30°C at all times. Determine the heat transfer for this process. (13分)
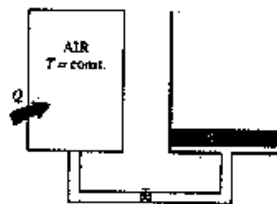
11. An ordinary egg can be approximated as a 5.5-cm-diameter sphere. The egg is initially at a uniform temperature of 15 °C and is dropped into boiling water at 97 °C. Taking the properties of the egg to be $\rho = 1020$ kg/m³ and $C_p = 3.32$ kJ/(kg·°C), determine (a) how much heat is transferred to the egg by the time the average temperature of the egg rises to 70 °C, and (b) the amount of entropy generation associated with this heat transfer process. (15分)