



Prob. 1 (30%)

The model of a motor with input voltage $f(t)$ and output angular velocity $y(t)$ is given as following, $y' + y = f(t)$, with $y(0) = 0$ where $f(t)$ is given in figure 1.

(1) Please solve $y(t)$ by Laplace transform. (15%)

(2) Please solve $y(t)$ by convolution integral (15%)

defined as $\int_0^t g(t-\tau)f(\tau)d\tau$.

Where $g(t)$ is the unit impulse response, that is the solution of $y' + y = \delta(t)$

with the unit impulse function (Dirac delta function) $\delta(t)$.

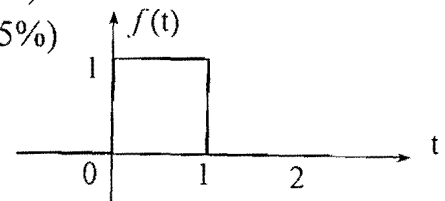


Figure 1

Prob. 2 (20%)

Given an equations as below

$$y' + 2y = 2 \cos(2x)\sin(4x),$$

please solve its particular solution $y_p(x)$.



3. Consider the system of linear equations:

$$2X_1 + X_2 - 11X_3 = -6$$

$$-5X_1 + X_2 + 9X_3 = 12$$

$$X_1 + X_2 + 14X_3 = -5$$

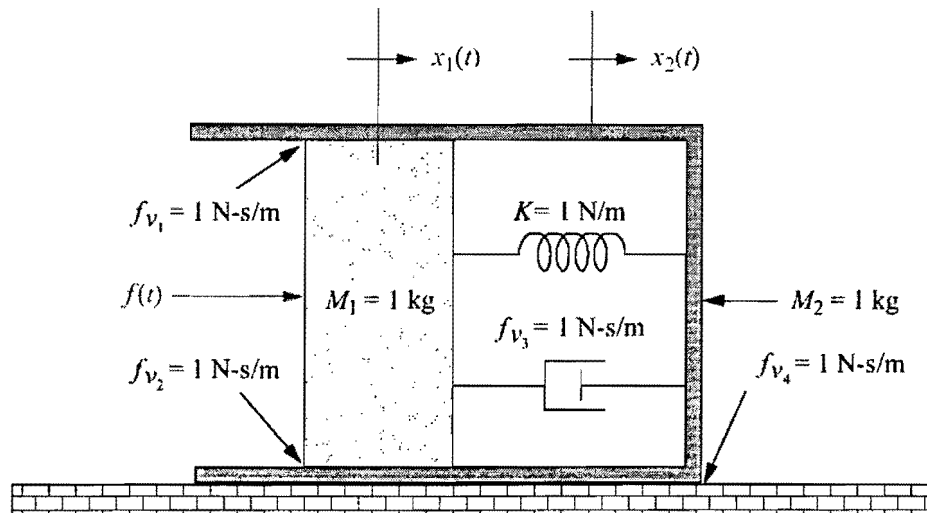
The system can be written in matrix form as $AX = B$. Please find (1) A, B, (2) the Rank of matrix A by Gauss elimination, (3) $\det(A)$, (4) A^{-1} , (5) $A^{-1}B$, (6) X. (25%)

4. Solve $\frac{\partial u}{\partial t} = 9 \frac{\partial^2 u}{\partial x^2}$ for $0 < x < 3, t > 0$

with $u(0,t) = u(3,t) = 0$ for $t \geq 0$; $u(x,0) = 50$ for $0 \leq x \leq 3$ (25%)



1. Find the transfer function, $G(s) = X_2(s) / F(s)$, for the system shown below (25%)



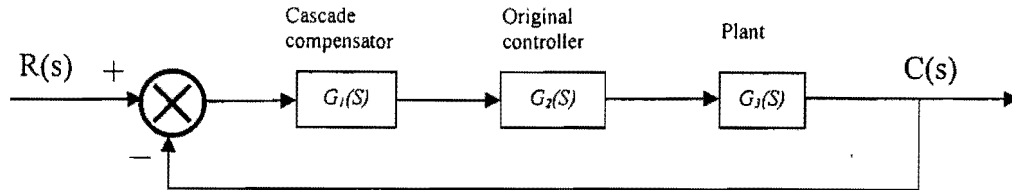
2. For a unity feedback system with transfer function $G(s)$ shown below, do the following: (25%)

$$G(s) = \frac{K}{(s+1)^3(s+4)}$$

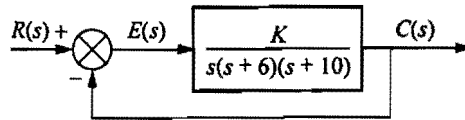
- Find the range of K for stability. (10%)
- Find the value of K for marginal stability. (5%)
- Find the frequency of oscillation when the system is marginally stable. (10%)



3. 如下圖，被控制系統 $G_3(s)$ 與原控制器 $G_2(s)$ 無法滿足性能需求，於根軌跡技術的基礎下，試依下述提問回答 cascade compensator 的設計問題。 25%



- 試說明 3 類能改善穩態誤差(steady state error)的 cascade compensators.
 - 試說明 3 類能改善暫態反應(transient response)的 cascade compensators.
 - 試說明前述解答中能以 passive network 實現的 cascade compensators (測試對此領域的通盤理解程度)
4. 被控制系統如下圖所示；請設計補償器，使補償後系統的 %OS 與補償前相同維持在 20%、補償後系統的 T_s 降為補償前的 50%、補償後系統的 steady state error 降為補償前的 10%；請以簡圖及簡短的註解，說明補償器的完整設計流程。 25% (可能涉及的公式如後所列；不需詳細作圖，只要顯示你知道怎樣解題即可)



$$T_p = \frac{\pi}{\omega_d \sqrt{1-\zeta^2}} = \frac{\pi}{\omega_d}$$

$$\%OS = e^{-\zeta\pi/\sqrt{1-\zeta^2}} \times 100\%$$

$$T_s \cong \frac{4}{\zeta\omega_n} = \frac{4}{\sigma_d}$$

$$\zeta = \cos \theta$$



1. 請說明為何大多數金屬中加入合金元素對彈性模數影響不大，然而對強度的影響卻很大。
(10%)
2. 請分別說明拉伸試驗(tensile test)及衝擊試驗(impact test)的目的，及其所能獲得的材料機械性質。
(10%)
3. 請畫出一般金屬拉伸試驗之工程應力-應變曲線(stress-strain curve)，並於圖上標出 yield strength (σ_y)、tensile strength (σ_{ts})及 ductility (ϵ_f) 位置。若當材料有一應變 ϵ ($\epsilon < \epsilon_f$)，請於圖上標出此材料達到此應變量時，於單位體積須要作功的大小。
(10%)
4. 已知對鐵進行滲碳熱處理 10h 後，將使距表面 2.5mm 處之碳濃度升到 0.45 wt.%，請估算此鐵金屬在相同滲碳溫度下，距表面 5.0 mm 處達到相同濃度所需的時間。
(10%)
5. 何謂定位精度，通常可分為哪四項，請分別簡述之？
(10%)



6. Diffusion is often used to enhance the hardness of the steel. Please write down the definitions of the following terms in diffusion, the phenomenon of material transport by atomic motion. (20%)
- (a) Vacancy Diffusion
 - (b) Interstitial Diffusion
 - (c) Steady-State Diffusion
 - (d) Nonsteady-State Diffusion
7. 請簡述積體電路(Integrated Circuits)製造中薄膜沉積之製程原理 (15%)
- (a) 蒸鍍 (Evaporation)
 - (b) 濺鍍 (Sputtering)
 - (c) 化學氣相沉積 (Chemical Vapor Deposition)
8. 在雷射加工製程中，請舉出三種常用的雷射種類，而加工工件影響加工效率的物理參數有哪些？(請舉出三個)。在雷射加工中通常有氣體來輔助加工，請說明理由。(15%)



1. A simple beam AB with span length $L=14$ m supports a uniform load of intensity q that includes the weight of the beam (see Figure 1). The beam is constructed of three plates of the same thickness welded together to form the cross section shown in the figure.

- (1) Find the moment of inertia I of the cross section.
- (2) Determine the maximum permissible load q based upon:
 - (a) an allowable bending stress $\sigma_{\text{allow}}=110$ MPa, and
 - (b) an allowable shear stress $\tau_{\text{allow}}=50$ MPa.

(25%)

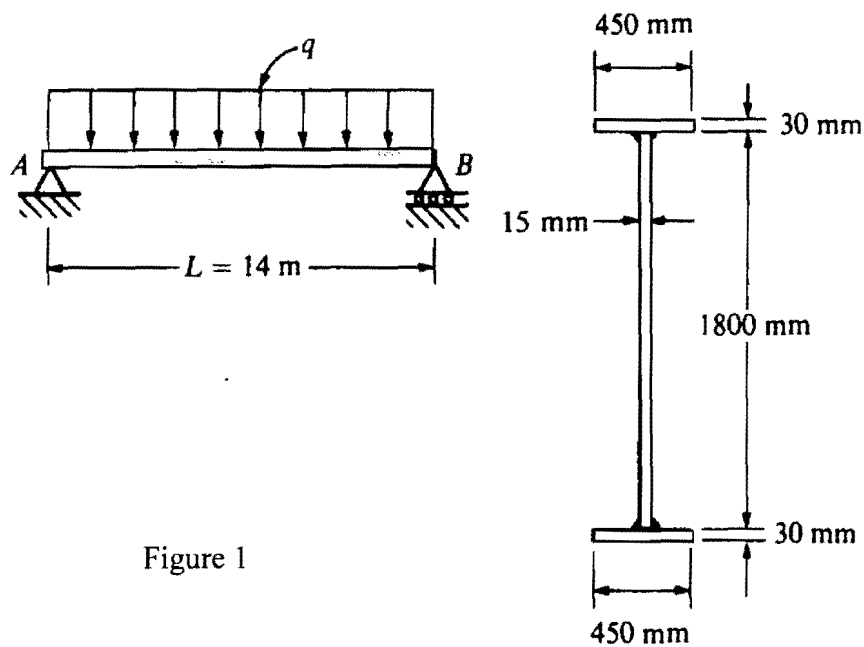


Figure 1



2. A stepped shaft is subjected to three torques as shown in Figure 2. The left end of the stepped shaft is fixed on a wall. The length of each section is 0.5 m and the diameters are 80 mm, 60 mm, and 40 mm. The material is steel with shear modulus of elasticity $G=80$ GPa.
- Find the reaction torque at the fixed end.
 - Calculate the maximum shear stress $\tau_{\max}$ in the shaft.
 - Calculate the angle of twist ϕ (degrees) at the free end.

(25%)

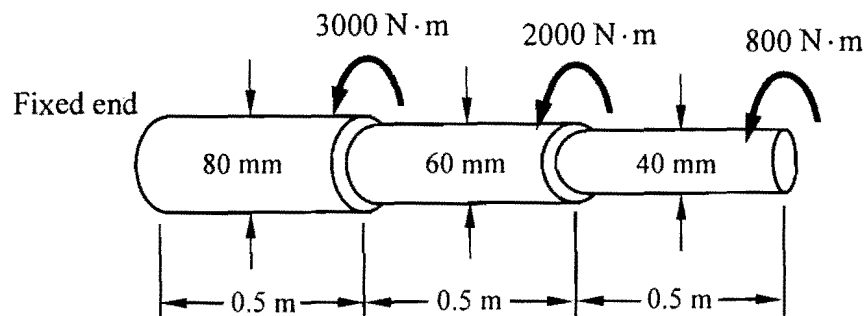
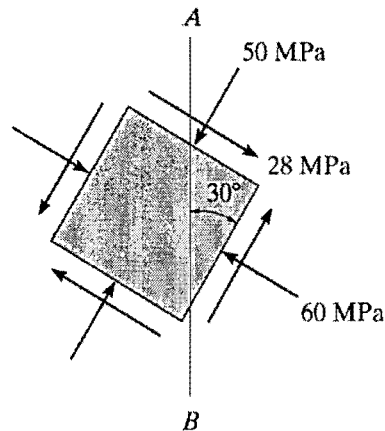


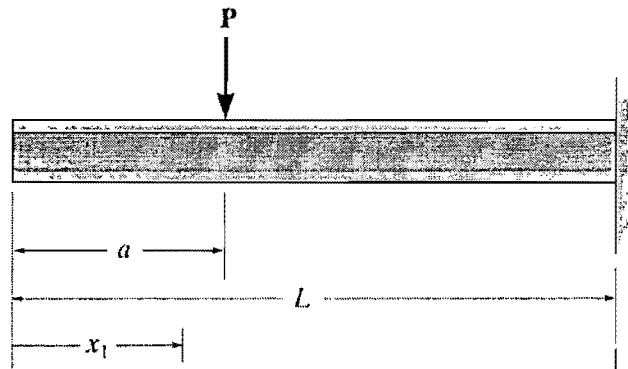
Figure 2



3. The state of stress at a point in a member is shown on the element. (a) Determine the stress components acting on the inclined plane AB . (b) Determine the principal stresses at the point and the orientation of the element upon which they act. (c) Determine the maximum in-plane shear stress and the corresponding average normal stress at the point. Also specify the orientation of the element upon which they act. [9%+8%+8%]

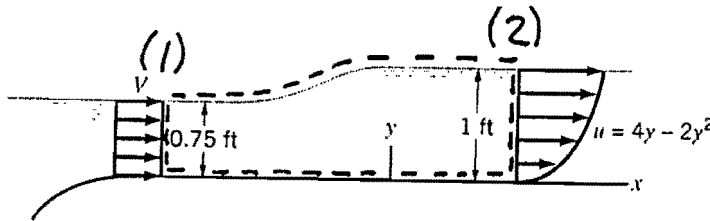


4. (a) Determine the equations of the elastic curve of the beam as shown and assume that EI is constant. (b) Determine the maximum deflection of the beam. (c) Determine the slope at the free end (the left end). [13%+6%+6%]

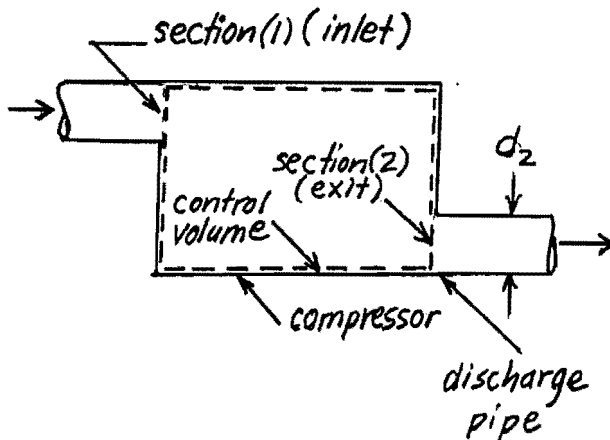




1. As shown in the following figure, at the entrance to a 3-feet-wide channel the velocity distribution is uniform with a velocity V . Further downstream the velocity is given by $u=4y-2y^2$, where u is in ft/s and y is in feet. Determine the value of V . 25%

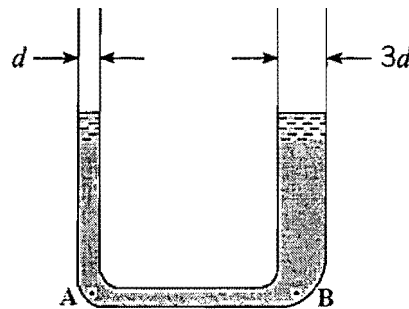


2. Air at standard atmospheric conditions is drawn into a compressor at the steady rate of $30\text{ m}^3/\text{sec}$. The compressor pressure ratio, $P_{\text{exit}}/P_{\text{inlet}}$, is 10 to 1. Through the compressor P/ρ^n remains constant with $n=1.4$. If the average velocity in the compressor discharge pipe is not to exceed 30 m/s, calculate the minimum discharge pipe diameter required. 25%





3. The manometer shown contains water at room temperature and is opened to the atmosphere. The glass tube on the left has an inside diameter of 1mm ($d = 1\text{mm}$). The glass tube on the right is three times as large. (25%)
- Is water surface level in the left tube higher than, equal to, or lower than the water surface level in the right tube? Why?
 - When considering the effect of surface tension, will the answer above change? Why?
 - If the top of the left tube is sealed and the air gauge pressure inside is 0.01atm, then which side has higher water surface level? Why?
 - If the manometer moves at a constant velocity to the right, which point will have a higher pressure? A or B? Why? (A and B are at the bottom of the left and right tube respectively)
 - If the manometer is now accelerated at a constant rate to the right, then which point will have a higher pressure? Why?



4. Water flows steadily through a horizontal circular pipe, (25%)
- Draw the time-averaged velocity profile for flow under laminar and turbulent condition.
 - Draw the shear stress distribution across the pipe's diameter, i.e., shear stress(τ) vs. radial position(r).
 - Describe the relationship between the pressure drop through the pipe and the pipe length. (use words such as proportional, inversely proportional, linear, non-linear, to the power of 2, etc.)
 - Describe the relationship between the pressure drop through the pipe and the pipe diameter with the mass flow rate and friction factor staying the same.
 - Describe the relationship between the pressure drop through the pipe and the averaged velocity inside the pipe.