國立雲林科技大學 102 學年度 系所：機械系
碩士班暨碩士在職專班招生考試試題 科目：工程數學(1)

1. Solve the following ordinary differential equation.

   $x^2y'' - 4xy' + 6y = x^4e^x$,

   $y(2) = 2$, $y'(2) = 7$ (25%)

2. Show the following Laplace transforms of functions.

   (a) $L[e^{at}] = \frac{1}{(s-a)}$ (10 %)

   (b) $L[\sin bt] = \frac{b}{s^2+b^2}$ (15%)

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Prob. 3 (15%)

A vector $\vec{v}=\begin{bmatrix}1\\-2\\-1\end{bmatrix}$ with respected to the basis $\left\{\begin{bmatrix}1\\-1\\1\end{bmatrix},\begin{bmatrix}1\\1\\0\end{bmatrix},\begin{bmatrix}1\\0\\1\end{bmatrix}\right\}$.

Please find the components of the vector with respected to the basis

$$\left\{\begin{bmatrix}1\\0\\0\end{bmatrix},\begin{bmatrix}0\\1\\0\end{bmatrix},\begin{bmatrix}0\\1\\1\end{bmatrix}\right\}$$

Prob. 4 (35%)

For the system $\dot{Y}=\mathbf{A}Y+H$

where $Y=\begin{bmatrix}y_1\\y_2\end{bmatrix}$, $\mathbf{A}=\begin{bmatrix}5&8\\-6&-9\end{bmatrix}$, $H=\begin{bmatrix}1\\t\end{bmatrix}$

(1) Evaluate the eigenvalues of **A**。

(2) Evaluate the eigenvactors X_1, X_2 of **A**。

(3) Evaluate $\mathbf{D}=\mathbf{X}^{-1}\mathbf{A}\mathbf{X}$ where $\mathbf{X}=[X_1, X_2]$

(4) Let $Y=\mathbf{X}Z$ and substituting into the system, please find the equation for Z.

(5) Let $Y(0)=\begin{bmatrix}4\\-3\end{bmatrix}$, please solve $Y(t)$

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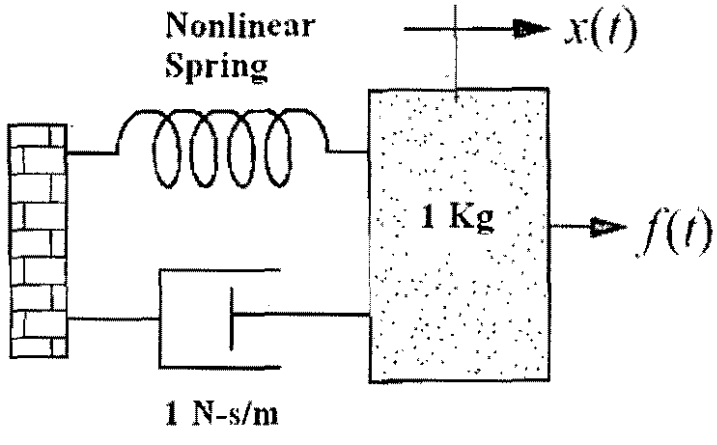
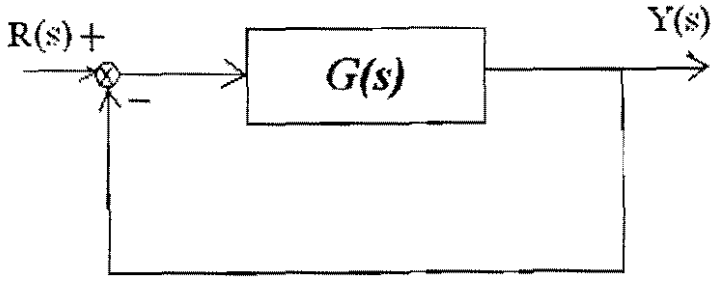
1. For the translational mechanical system with a nonlinear spring shown below. The spring constant is defined by $x(t)=1-e^{-fs(t)}$, where $x(t)$ is the spring displacement and $fs(t)$ is the spring force.
   (a) Write the nonlinear differential equation of motion for the system. (10%)
   (b) Find the linearized transfer function, $G(s)=X(s)/F(s)$, for small excursions around $f(t)=1$. (15%)
   [Hint: (1) $y = e^x$ --> $\ln y = x$; (2) $d(\ln y)/dy = 1/y$]



2. A unity negative feedback system has the plant transfer function

$$G(s) = \frac{K}{s(s+\sqrt{2K})}.$$



   (a) Determine the $\%OS$ and T_s (settling time) due to a unit step input. (10%).
   (b) For what range of K is the settling time less than 1 second? (15%)

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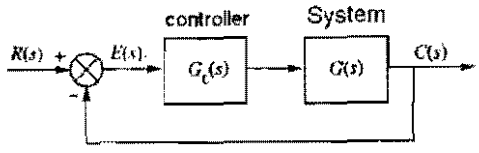
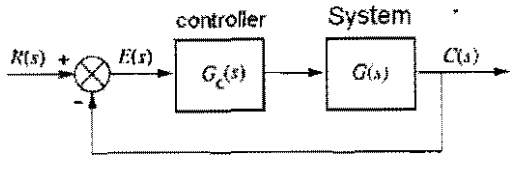
3. 如下圖，被控制系統 G(s)無法滿足性能需求，基於根軌跡技術，試依下述提問回答 controller 的設計問題。 25%



a. 試說明「純積分器」、「PI controller」、「Lag Compensator」等三類 controller，係用於改善系統的何種性能指標？三類 controller 的功能有何差異？

b. 試說明「純微分器」、「PD controller」、「Lead Compensator」等三類 controller，係用於改善系統的何種性能指標？三類 controller 的功能有何差異？

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 15%、補償後系統的 T_s 降為補償前的 1/3、補償後系統的 steady state error 降為補償前的 1/10；請詳列補償器的設計流程。 25%



$$G(s) = \frac{K}{s(s+5)(s+12)}$$

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi}{\omega_d} \qquad \%OS = e^{-\zeta\pi/\sqrt{1-\zeta^2}} \times 100\%$$

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

（可能涉及的公式，請參考）

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1. (a) Explain briefly what is meant by a dislocation.

(5%)

(b) Show how dislocations can account for the following observations:

(i) cold working makes aluminum harder;

(ii) an alloy of 20% Zn, 80% Cu is harder than pure copper;

(iii) the hardness of nickel is increased by adding particles of thorium oxide.

(15%)

2. 試簡述說明以下4種幾何量測原理:「比較測量原理」、「阿貝比長原理」、「正弦正切原理」和「圓周封閉原理」。

(15%)

3. 就結構設計與製造加工上的考量，比較說明常用於自行車車架使用之鉻鉬鋼、鋁合金及碳纖維的特性，及其應用於自行車製造成型上可能使用之加工方法。

(15%)

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4. 請說明硬度測試時的基本原理並就下列硬度測試方法進行測試程序上的說明:
(1) Brinell Test
(2) Rockwell Test
(3) Vickers Test　　(20%)

5. 高分子材料之應用日趨廣泛，其特性迥異於一般金屬材料。請說明下列高分子材料特性:
(1) Glass-transition Temperature
(2) Thermoplastics
(3) Thermosetting Plastics　　(15%)

6. 積體電路(IC)的製造程序中，分爲溼式蝕刻與乾式蝕刻兩種。請列舉三種乾式蝕刻的方法並簡述其原理。　　(15%)

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1. A rod AB has two different cross-sectional areas as shown in Figure 1. The rod is rigidly attached to immovable supports at the ends and is loaded by equal and opposite forces P at the locations shown. Determine the axial stress σ at the middle of the rod, assuming A_1 is the cross-sectional area near the ends, and A_2 is the cross-sectional area in the middle region. (Use numerical data as follows: P=5400 lb, A_1=0.6 in.^{2}, A_2=0.9 in.^{2}, and b=1.5a.)

(25%)

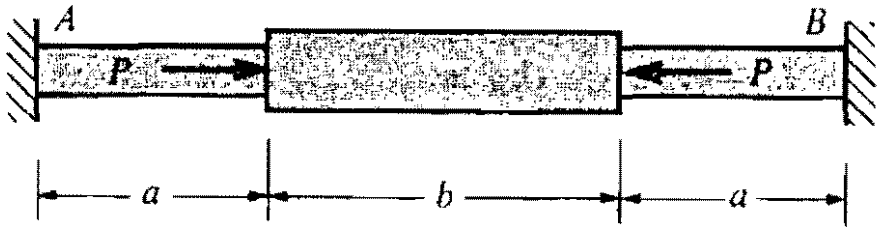

Figure 1

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2. A solid shaft is formed of two materials, an outer sleeve of steel (shear modulus G_s=80 GPa) and an inner rod of brass (shear modulus G_b=36 GPa), as shown in Figure 2. The outside diameters of the two parts are 75 mm and 60 mm. Assuming that the allowable shear stresses are τ_s=80 MPa and τ_b=48 MPa in the steel and brass, respectively. Determine the maximum permissible torque T that may be applied to the shaft.

(25%)

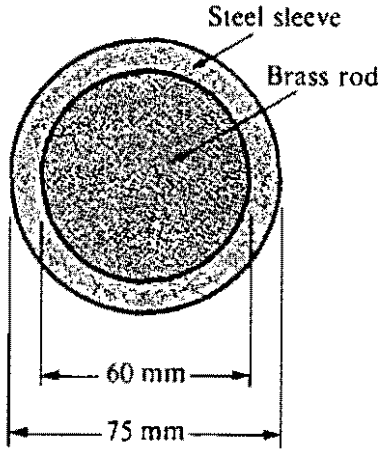

Figure 2

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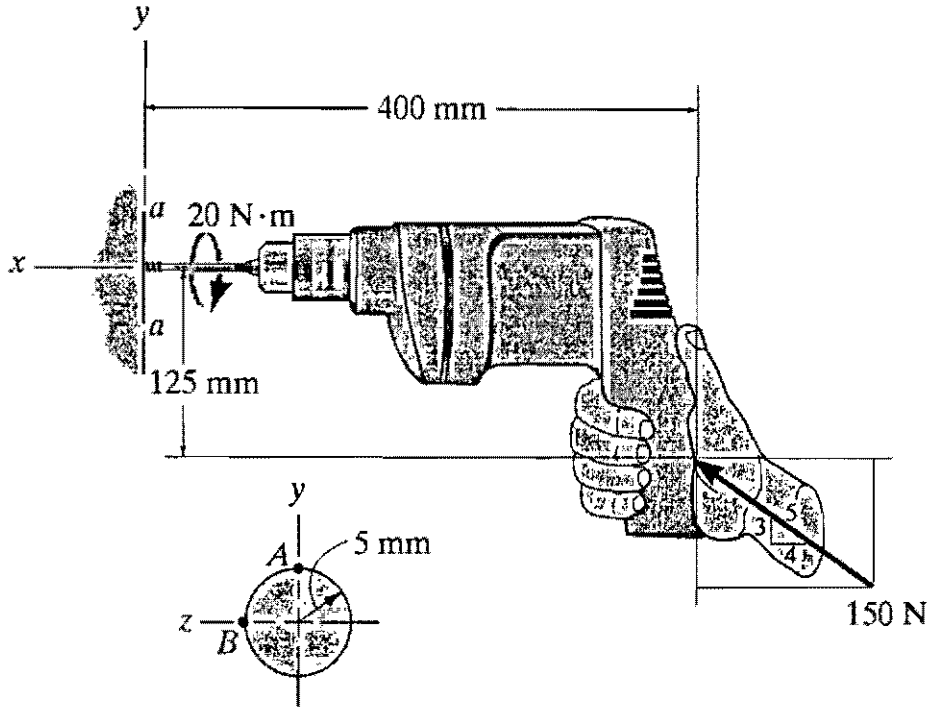
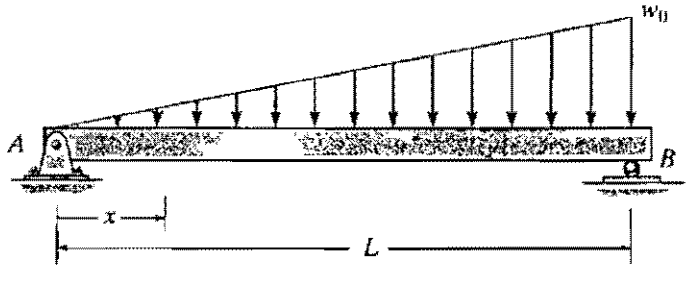
3. The drill is jammed in the wall and is subjected to the torque and force shown. Determine the state of stress at point *B* on the cross section of drill bit at section *a-a*. The distance from the centroid of a semi-circle to its boundary diameter is $4r/3\pi$. [25%]



Section *a* – *a*

4. The beam is subjected to the linearly varying distributed load, and *EI* is constant. (a) Determine the maximum deflection of the beam. (b) Determine the maximum slope of the beam. [25%]



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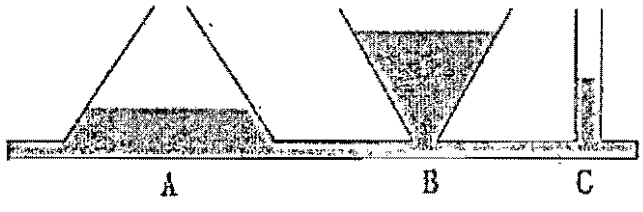
1. Three containers connected at the base are filled with a liquid. The top of each container is open to the atmosphere and surface tension is negligible. The container shapes are all different. (a) Is the fluid level in the containers at **equilibrium conditions** shown in the figure correct? If not, what should it look like? (b) A, B and C represent the locations at the base of each container as shown. Based on your answer in (a), which point has the highest pressure? Why? (25%)



2. Water flows steadily through a horizontal circular pipe from a reservoir. (a) Compare the Energy Grade Line (EGL) for different pipe diameters with same water level in the reservoir under the **ideal** and **real** situations; (b) Under which flow situation, the wall shear stress will be lower? Laminar or turbulent? Why? (c) How does the wall shear stress vary along the pipe in the entrance region (developing flow)? (25%)

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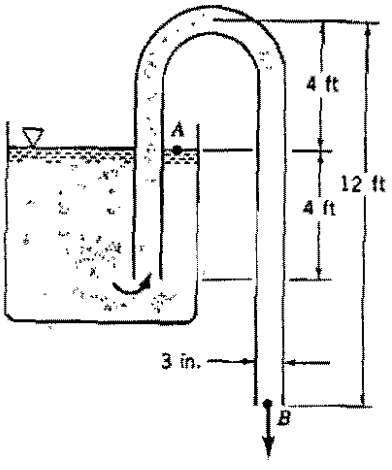
3. A water siphon (虹吸管) has a constant inside diameter of 3 inches. If the friction loss between A and B is $0.6V^2/2$, where V is the velocu of flow in the siphon, determine the flow rate involved. **25%**



4. Assume the flow around the long circular cylinder is non viscous and incompressible. Two pressures, P_1 and P_2, are measured on the cylinder surface. It is propose that the free stream velocity, U, can be related the the pressure difference, $\Delta P = P_1 - P_2$, by the equation

$$U = C\sqrt{\frac{\Delta p}{\rho}}$$

Where ρ is the fluid density. Determine the value of constant C. Neglect the body force. **25%**