# 國立中山大學九十三學年度碩士班招生考試試題

科目：工程數學（機械與機電工程學系碩士班）



選擇題部分（共 10 題，每題 5 分，答錯不倒扣）

[I] 第 1 至第 4 題為複選題

1. Consider the following partial differential equation (PDE),

$$a\frac{\partial^2 V}{\partial x^2}+2b\frac{\partial^2 V}{\partial x\partial y}+c\frac{\partial^2 V}{\partial y^2}+d\frac{\partial V}{\partial x}+e\frac{\partial V}{\partial y}+fV+g=0$$

where a,b,c,d,e,f & g are constants. Which statements are correct?

(A) If $b^2 < ac$, then the PDE is an elliptic type PDE.

(B) If $b^2 = ac$, then the PDE is a hyperbolic type PDE.

(C) For an elliptic type PDE, the corresponding conditions are boundary conditions only.

(D) For an elliptic type PDE, the corresponding conditions are initial conditions only.

(E) None of the above.

2. If $r^2 = x^2 + y^2$, $x = r\cos\theta$, $y = r\sin\theta$, & $\tan\theta = y/x$, then which statements are correct?

(A) $\frac{\partial r}{\partial x}=\sin\theta$ (B) $\frac{\partial \theta}{\partial x}=\frac{-\sin\theta}{r}$ (C) $\frac{\partial r}{\partial y}=\cos\theta$ (D) $\frac{\partial \theta}{\partial y}=\frac{\cos\theta}{r}$ (E) None of the above.

3. Consider the PDE : $c\frac{\partial u}{\partial x}+\frac{\partial u}{\partial t}=0, -\infty < x < \infty \;\&\; t > 0$. Which statements are correct?

(A) If $c = 2$ & $u(x,0) = 1 + x^2$, then $u(x,t) = 1 + (x - 2t)^2$.

(B) If $c = -2$ & $u(x,0) = 1 - x^2$, then $u(x,t) = 1 - (x + 2t)^2$.

(C) If $c = 2$ & $u(x,0) = 1 - x^2$, then $u(x,t) = 1 - (x - 2t)^2$.

(D) If $c = -2$ & $u(x,0) = 1 + x^2$, then $u(x,t) = 1 + (x + 2t)^2$.

(E) None of the above.

4. Consider the matrix $\mathbf{A} = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$, then which statements are correct?

(A) Due to symmetry of matrix **A**, the matrix **A** has two identical eigenvalues.

(B) One of the eigenvalues of the matrix **A** is 2.

(C) Due to symmetry of matrix **A**, the two eigenvectors of the matrix **A** are parallel to each other.

(D) One of the eigenvectors of the matrix **A** is $\begin{bmatrix} 2 \\ 1 \end{bmatrix}$.

(E) None of the above.

[II] 第 5 至第 8 題為單選題

5. Let C be the circle $|z-2| = 2$, described in the positive sense. The integral $\frac{1}{\pi i}\oint_C \frac{3z^2+2}{(z-1)(z^2+9)}dz$ is (A) 1, (B) 2, (C) 4, (D) 6, (E) None of the above.

6. Evaluate the definite integral of $\frac{1}{2\pi}\int_0^{2\pi}\frac{d\theta}{5+4\sin\theta}$. Which of the following is the value of the integral? (A) 1/6, (B) 1/4, (C) 1/3, (D) 1/2, (E) None of the above.

7. Let $f(x)=|x|,\ (-\pi \le x \le \pi)$. It can be represented by the basic Fourier cosine series as

$$f(x)=a_0+\sum_{n=1}^{\infty}a_n\cos nx.$$

Which of the following is the value of $a_0$?

(A) 0, (B) 1.0, (C) 1.5, (D) $\pi/2$, (E) None of the above

8. Using the Fourier cosine series of the function given in Prob. 7, which of the following is the value of $\sum_{n=1}^{\infty}\frac{1}{(2n-1)^2}$?

(A) $2\pi/5$, (B) $\pi^2/8$, (C) $\pi^3/25$, (D) $\pi^4/80$, (E) None of the above.

[III] 第 9 至第 10 題為題組單選題

$P_1$, $P_2$, $R_1$, and $R_2$ are four different points in three-dimensional space. "•" and "×" denote symbols for the inner product and the cross product of vectors, respectively.

9. The length of the common perpendicular $Q_1Q_2$ to the lines $P_1R_1$ and $P_2R_2$ (i.e., $Q_1Q_2 \perp P_1R_1$ and $Q_1Q_2 \perp P_2R_2$) is

(A) $\dfrac{|\mathbf{P_1R_1}\bullet(\mathbf{P_1P_2}\times\mathbf{P_2R_2})|}{|\mathbf{P_1P_2}\times\mathbf{P_2R_2}|}$, (B) $\dfrac{|\mathbf{P_1R_1}\times(\mathbf{P_1P_2}\times\mathbf{P_2R_2})|}{|\mathbf{P_1P_2}\times\mathbf{P_2R_2}|}$, (C) $\dfrac{|\mathbf{P_1P_2}\bullet(\mathbf{P_1R_1}\times\mathbf{P_2R_2})|}{|\mathbf{P_1R_1}\times\mathbf{P_2R_2}|}$,

(D) $\dfrac{|\mathbf{P_1P_2}\times(\mathbf{P_1R_1}\times\mathbf{P_2R_2})|}{|\mathbf{P_1R_1}\times\mathbf{P_2R_2}|}$, (E) None of the above.

10. If intersection of the lines $P_1R_1$ and $P_2R_2$ exists, then

(A) $(\mathbf{P_1P_2}\times\mathbf{P_1R_1})\bullet(\mathbf{P_1P_2}\times\mathbf{P_1R_2})=0$, (B) $|(\mathbf{P_1P_2}\times\mathbf{P_1R_1})\times(\mathbf{P_1P_2}\times\mathbf{P_1R_2})|=0$,

(C) $|\mathbf{P_2R_2}\times(\mathbf{P_1P_2}\times\mathbf{P_1R_2})|=0$, (D) $|\mathbf{P_1R_1}\times(\mathbf{P_1P_2}\times\mathbf{P_1R_2})|=0$, (E) None of the above.

非選擇題部分（共 5 題，每題 10 分）

[IV] Define $v_t$ to be component of $\mathbf{v}=2y\mathbf{i}+z\mathbf{j}+3y\mathbf{k}$ in the direction of the tangent vector of curve $C$: the intersection of $x^2+y^2+z^2=6z$ and $z=x+3$, oriented in the clockwise sense as viewed from the origin. Evaluate $\int_C v_t ds$, where $s$ is the arc length.

[V] 求 $\int_0^{\frac{\pi}{2}}\sin^2\theta\cos^4\theta d\theta$ 之積分。

請用 （A）一般微積分的方法（B）複變數圍線積分的方法。

[VI] 求微分方程式 $\dfrac{d^2y}{dx^2}-3\dfrac{dy}{dx}+2y=xe^x$ 之通解。

[VII] Students have recorded the temperature and resistance measurements from their experiments. It is known that the relationship of these two variables can be described by the following linear equation

$$R = aT$$

where $R$ denotes resistance and $T$ represents the temperature. Conventionally, the proportionality constant $a$ is determined in such a way that the sum of the mean squares prediction errors is minimized. Note that the prediction error $e_i$ associated with the $i$th set of the experimental data can be specified by the following equation:

$$R_i = aT_i + e_i$$

After using this least squares approach for a number of times, the students discover that, generally speaking, this approach performs quite well. However, they also discover that this approach is very sensitive to outliers in the experimental data. Note that an outlier is an individual data that is atypical because it stands considerably apart from the general pattern. For example, if we mistakenly record a resistance value of 3.5 as 35, we will generate an outlier. Can you explain why the least squares approach is sensitive to outliers? Propose an idea to resolve this problem.

[VIII] In order to determine the rate of change of a signal $x(t)$. this signal $x(t)$ is experimentally collected as $x(t_i)$. Note that $t_i = iT$ with $T$ as the sampling period. One way to determine the rate of change for $x(t)$ is to use the following finite-difference equation:

$$\dot{x}(t) \approx \frac{x(t+T) - x(t)}{T}$$

However, after carefully testing this technique, it is found that the accuracy of this method is very sensitive to the measurement noise associated with $x(t_i)$. Unfortunately, such measurement error is often inevitable in practice. Please explain the reason behind the weakness of the above finite-difference technique. Please also propose a method to improve this problem.

**Thermodynamics: (65%)**

1. For a vapor power plant, the low pressure steam and water mixture need to be condensed into liquid water after leaving a steam turbine. Why? 5%

2. An insulated rigid tank is initially evacuated. A valve is opened and atmospheric air at 25℃, 1 atm enters until the pressure in the tank becomes 1 atm, at which time the valve is closed. Is the final temperature of the air in the tank equal to, greater than, or less than 25℃? 5%

3. Explain the meanings of humidity ratio, relative humidity, dew point temperature, dry-bulb temperature and wet-bulb temperature. 5%

4. If two samples of the same gas at the same temperature and pressure were mixed adiabatically, would entropy produce? 5%

5. For a fixed pressure and temperature process, how can you check if the reactive system attains its equilibrium state? 5%

6. Please derive the first law efficiencies for idea heat engines(or power plants), refrigerators, and heat pumps between two thermal reservoirs T and $T_o$. In the derivation of the equations of the first law efficiencies, we assume the specific heats $C_p$ and $C_v$ are constants. Use these derived results to make a plot to denote the cycle maximum theoretical efficiencies of the three types of devices. In this plot, please display the upper bound equations of the first law efficiencies obtained from the assumptions of the idea models. In a heat engine and a heat pump, the high temperature thermal reservoir is denoted as T, and the low temperature thermal reservoir is denoted as $T_o$. However, in a refrigerator, the high temperature thermal reservoir is denoted as $T_o$ and the low temperature thermal reservoir is denoted as T. In this plot, the ordinate could be thermal efficiency of heat engine, the coefficient of performance of refrigerator, or the coefficient of performance of heat pump, and the abscissa is $T/T_o$. 10%

7. Over a certain temperature interval, the saturation pressure-temperature curve of a substance is represented by an equation of the form $\ln p_{sat} = A - B/T$, where A and B are empirically determined constants. Obtain expressions for $h_g - h_f$ and $s_g - s_f$ in terms of p-v-T data and constant B. 15%

8. Please explain the differences between (a) Carnot Cycle, (b) Rankine Cycle, and (c) Brayton Cycle by T-S and P-V curves of cycles. Why Carnot Cycle has the highest " efficiency" ? (15%)

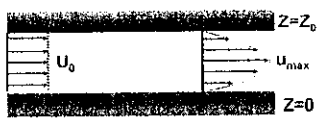
**Heat Conduction and Radiation: (35%)**

9. A steam pipe of length L = 20 m, inner radius = 6 cm, outer radius = 8 cm, and thermal conductivity k = 20 W/m・℃. The inner and outer surfaces are maintained at average temperatures of 150℃ and 60℃ respectively. Please obtain a general relation for the temperature distribution inside the pipe under steady conditions and determine the rate of heat loss from the pipe. (15%)

10. A 0.8 m(height) x 1.5 m(width) double-panel window consisting of two 4 mm(thickness) layers of glass(**k** = 0.78 W/m・℃) separated by a 10 mm air space (**k** = 0.026 W/m・℃). Determine the rate of heat transfer (steady state) and the temperature of inner surface. The room temperature is 20℃ while the outdoor temperature is -10℃. The convection heat transfer coefficients are $\mathbf{h}_1$ = 10 W/m²・℃ and $\mathbf{h}_2$ = 40 W/m²・℃ for inner and outer surfaces of the window respectively. (10%)

11. Please define the following terms: (a) Blackbody, (b) Emissivity, (c) View(Shape) Factor (d) Reciprocity Rule, (e) Gray Surfaces. (10%)

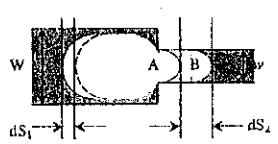
1. What is Coanda effect. (5%)
2. Give the definition of (a) steady flow (b) uniform flow. (5%)
3. For a two dimension flow, u = 1/t+1, v=1 and (x,y) = (1,1) at t = 0. Fine the (a) streamline (b) pathline and (c) streakline at t = 0. (10%)
4. The flow in the inlet between parallel plates is uniform, $u=U_0$ = 4 cm/s, while downstream the flow develops into the parabolic laminar profile $u=aZ(Z_0-Z)$, where a is a constant, If $Z_0$ = 1 cm and the fluid is glycerin at 20°C, for steady flow what is the value of $u_{max}$ in centimeters per second? (10%)




5. For a uniform laminar flow between two parallel plates with the velocity distribution of $\frac{u}{U}=a+b\eta+c\eta^2$ , $\eta=\frac{y}{\delta}$ where U: free stream velocity, δ: boundary layer thickness, y: distance between the two plates, assume the molecule kinematic viscosity is μ. Please find
   (a) boundary layer thickness δ ( 3 %)
   (b) displacement thickness $\delta^*$ ( 3 %)
   (c) momentum thickness θ ( 3 %)
   (d) shear stress on the wall $\tau_w$ ( 3 %)
   (e) surface friction coefficient $C_f$ ( 3 %)

6. For a bubble in a microchannel, the surface energy difference of the gas bubble between state A and B can be expressed as:

   $$dE=2\gamma_{lg}(h+w)dS_2-2\gamma_{lg}(h+W)dS_1$$ Where



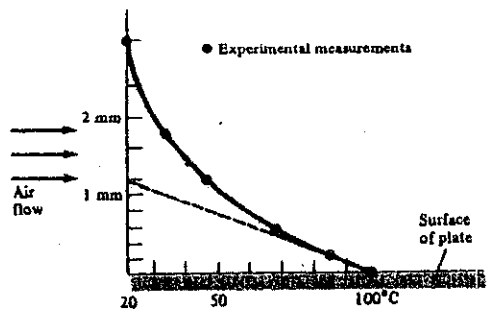

   E: surface energy

   $\gamma_{lg}$: surface energy between per unit area between liquid and gas

   h: the depth of the channel
   w: the width of the narrower channel
   W: the width of the wider channel
   Derive the minimum pressure required to drive the bubble from state A into state B. Assume the geometry of the bubble is a 2-dimentional shape. (10 %)

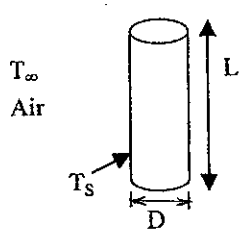
7. (8%) Consider hydrodynamically and thermally fully developed flow in a circular tube of constant cross-section. If the flow is laminar and the fluid properties are assumed to be temperature independent, what happens to the heat transfer coefficient if (a) the flow rate is doubled and the flow is still laminar, (b) the thermal conductivity is doubled, (c) the viscosity is doubled, (d) the diameter of the circular duct is doubled, while the flow rate is the same?

8. (7%) Air at 20°C is flowing over a flat plate whose surface temperature is 100°C. At a certain location the temperature is measured as a function of distance from the surface of the plate; the results are plotted in the following figure. From these data determine the convection heat transfer coefficient at this location.
(thermal conductivity of air k=0.028 W/mK,
、thermal conductivity of the flat plat k=15.1 W/mK)




9 (9%) Consider natural convection of a vertical heated cylinder in air, as shown in the figure. (D is the diameter, and L is the length of the cylinder)

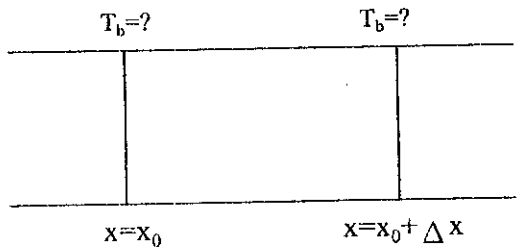
(a) What physical quantities does the heat transfer rate depend on?
(b) Do you expect higher heat transfer rate if the cylinder were on the moon, instead of on the Earth, with the other conditions remaining the same.




(c) Do you expect higher heat transfer rate in case that the cylinder is horizontal, instead of vertical? Explain your answer (note: D<<L)

10 (6%) For a horizontal fluid flow over a vertical cylinder, as shown in Problem 9,
(a) give the definition of Reynolds number and its physical meaning.
(b) give the definition of Prantdl number and its physical meaning
(give meaning of any symbol if used)

11. (15%) Water in a circular pipe has velocity distribution $u(r)/U_{max}=\{1-(r/R)^2\}$ and temperature distribution $(T-T_0)/(T_{max}-T_0)=\{1-(r/R)^2\}$, at the section $x=x_0$, where R=10cm is the radius of the pipe, $U_{max}$=0.2cm/s is the water velocity at the centerline(r=0), $T_{max}$=20℃ is water temperature at r=0, and $T_0$=100℃ is the temperature of the pipe surface (r=R) at $x=x_0$.
Assume $\rho=10^3$ kg/m$^3$, Cp=4200 J/kg·K for water, answer the following questions
(a) What is the mass flow rate at the section at $x=x_0$?
(b) What is the bulk temperature at $x=x_0$?
(c) Under a constant heating with heat flux $q=50w/m^2$, what is the bulk temperature at $x=x_0+\Delta x$? ($\Delta x$=1m)



# 國立中山大學九十三學年度碩士班招生考試試題

科目：應用力學 【機械與機電系碩士班 乙、丙組】



I. Multiple Choices.( Please choose one or more correct statements for each of the following question.)

(1) In the basic characteristics of the frictional force acting between bodies in contact, which statements in the following are correct? (5%)

(A) Friction is a force that exists between two bodies in contact. It is tangent to the contact surface between the bodies and opposes sliding motion between the bodies.

(B) A frictional force is proportional to the normal force between contacting bodies and to the area of contact between the bodies.

(C) The coefficient of static friction is the ratio of the maximum static frictional force to the normal force for bodies in contact.

(D) The kinetic frictional force is always larger than the maximum static frictional force.

(E) The maximum static friction is the maximum frictional force that can exist between bodies in contact. It occurs when sliding motion between the bodies is impending.

(2) In the principles of equilibrium of rigid bodies, which statements in the following are correct? (5%)

(A) If the resultant force of three concurrent forces that act on a rigid body is zero, the body is in equilibrium.

(B) A rigid body subjected to coplanar forces is in equilibrium if the moments about any three points in the plane are zero.

(C) If the resultant force of a system of forces that acts on a rigid body is zero, the sum of the moments of the forces is the same about every point in the body.

(D) Any force system that acts on a rigid body can be replaced by a dynamically equivalent system consisting of a single force and single moment.

(E) There are three independent scalar equations of equilibrium can be written for a rigid body.

(3) In the principles of forces, couples, and equilibrium of rigid bodies, which statements in the following are correct? (5%)

(A) A couple that acts on a rigid body produces the same effect on the body if it is moved to a plane normal to its original plane.

(B) If a rigid body is in equilibrium, every part of the rigid body is in equilibrium.

(C) A straight two-force member that is in equilibrium must be subjected to a compressive force at one end and a tensile force at the other end.

(D) There are two essential properties of a force – magnitude and sense.

(E) A couple always tends to rotate a rigid body on which it acts about the midpoint of the arm of the couple.

(4) In a collision between two bodies, which statements in the following are correct? (5%)

(A) In an inelastic collision, momentum is not conserved.

(B) The coefficient of restitution is the ratio of the final and initial kinetic energies of the system.

(C) In a perfectly plastic collision, all the kinetic energy of the system is lost.

(D) An elastic collision is one in which both kinetic energy and momentum are conserved.

(E) During an elastic collision, compression of the colliding bodies is fully recovered.

(5) In the work and energy principles for particles and rigid bodies, which statements in the following are correct? (5%)

(A) The vector product of force and velocity is power.

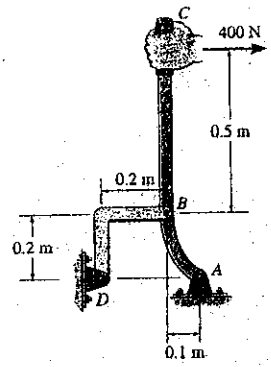
(B) The time rate of change of work is equal to the time rate of change of kinetic energy.

(C) A force that acts on a particle in a direction perpendicular to the path on which the particle travels does no work on the particle.

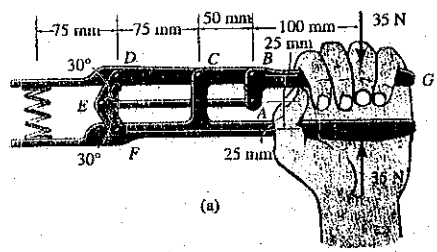
(D) Work is always a non-negative, scalar quantity.

(E) A couple performs positive work on a rigid body if the body rotates in the same direction as the couple acts.

2. The lever ABC is pin-supported at A and connected to a short link BD. If the weight of the members is negligible, determine the force of the pin on the lever at A (10%)



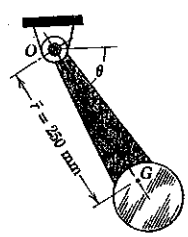

3. The hand exerts a force of 35 N on the grip of the spring compressor. Determine the force in the spring needed to maintain equilibrium of the mechanism. (15%)




4. The pendulum has a mass of 7.5 kg with center of mass at G and has a radius of gyration about the pivot O of 295 mm. If the pendulum is released from rest at θ = 0 and the bearing friction is negligible, find the following when θ = 60 degrees

a) The angular acceleration = _____ ( rad / $s^2$)

b) The total force supported by the bearing = _____( N ) (25%)

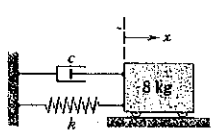



5. The 8-kg body is moved 0.2 m to the right of the equilibrium position and released from rest at time t = 0. The viscous damping coefficient c is 20 N•s/m and the spring stiffness *k* is 32 N /m.

a) Find the damped natural frequency = _____

b) Determine its motion of equation, x = _____

( hint : x = A sin (Bt+ C) ) (25%)



單選選擇題 ((1)~(5), 每題 7 分, 答錯不倒扣)

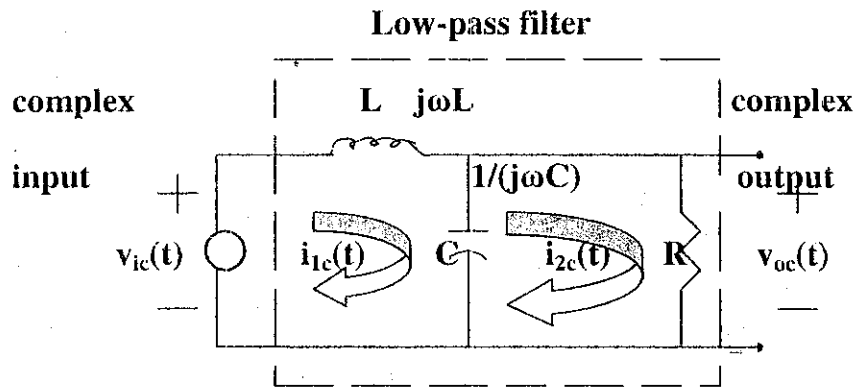
(1). (7%)Find the complex voltage to complex voltage transfer function $H(\omega) = v_{oc}(t)/v_{ic}(t)$ for Figure 1. $H(\omega)$ = ?

(A). $-(\omega^2LC)/[(1-\omega^2LC)+j(\omega L/R)]$ (B). $1/[(1-\omega^2LC)+j(\omega L/R)]$

(C). $-(\omega^2LC)/[(1-\omega^2LC)-j(\omega L/R)]$(D). $1/[(1-\omega^2LC)-j(\omega L/R)]$

(E). the above are all wrong.

Figure 1:




(2). (7%)The unit-step response of a standard second-order system is $c(t) = 1-1.24e^{-3.85t}\sin(5.26t + 53.8^\circ)$, and the damping ratio is $\zeta$, natural frequency is $\omega_n$. Then, we approximately get

(A). $\zeta = 0.32$, $\omega_n = 5.42$ (B). $\zeta = 0.91$, $\omega_n = 1.54$ (C). $\zeta = 0.59$, $\omega_n = 6.50$

(D). $\zeta = 1.25$, $\omega_n = 3.96$ (E). the above are all wrong.

(3). (7%)When we sketch the root locus for a unity-feedback system with $G(s)=K/[s(s+1)(s+2)]$, the root locus branches that extend to the right-half s-plane cross the imaginary axis at $s= \pm j\omega_d$, and $\omega_d$ is about

(A). 1.414 (B). 1.612 (C). 2.432 (D). 3.244 (E). the above are all wrong.

(4). (7%)We use MATLAB M-file to sketch the root locus for a unity-feedback system with $G(s)=K/[s(s+1)(s+2)]$, and the root locus branches that extend to the right-half s-plane cross the imaginary axis at $s= j\omega_d$. What statement we use to find out $j\omega_d$, and gain K at this $j\omega_d$? (A)[K, poles] = rloc(num,den)

(B) [K, poles] = rlocusfind(num,den) (C) [K, poles] = rootfind(num,den)

(D) [K, poles] = locusfind(num,den) (E) the above are all wrong.

(5). (7%)Which of the following statements is correct?

(A). The necessary and sufficient condition that all the poles lie in the left half s-plane is that all the coefficients of the characteristic equation $q(s) = a_ns^n+a_{n-1}s^{n-1}+\cdots+a_1s+a_0 = 0$ are positive.

(B). Nonminimum-phase system is an unstable system.

(C). For the linear time-invariant system, $dx(t)/dt=Ax(t)+Bu(t)$, with a state-feedback control, $u(t)=-Kx(t)$, is applied, then we can use the Routh-Hurwitz stability criterion to test the stability of the closed-loop system with the characteristic equation as $\det(sI-(A+BK)) = 0$ (if K is given).

(D). In general, raising the bandwidth will cause a faster system response.

(E). the above are all wrong.

(6). Derive the transfer function $E_o(s)/E_i(s)$ of the following circuits shown in (i). (7%)Figure 2a, and (ii). (8%)Figure 2b.

Figure 2a:

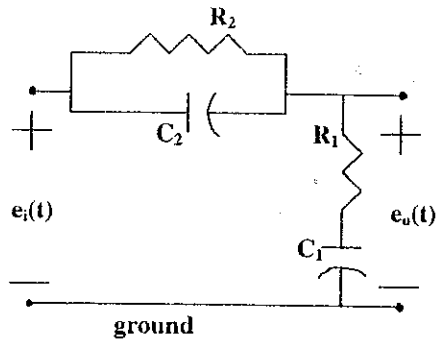
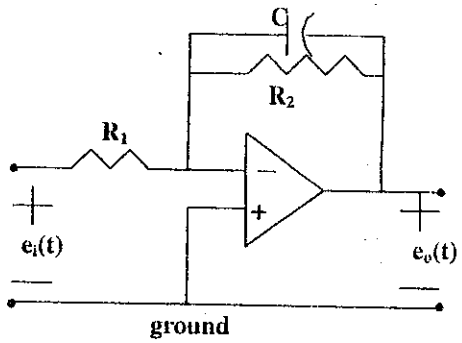
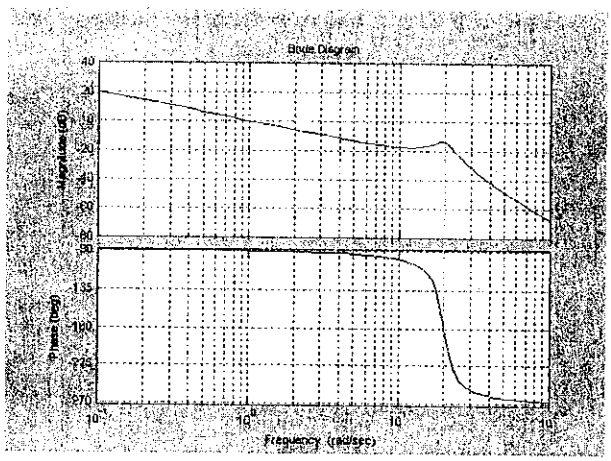


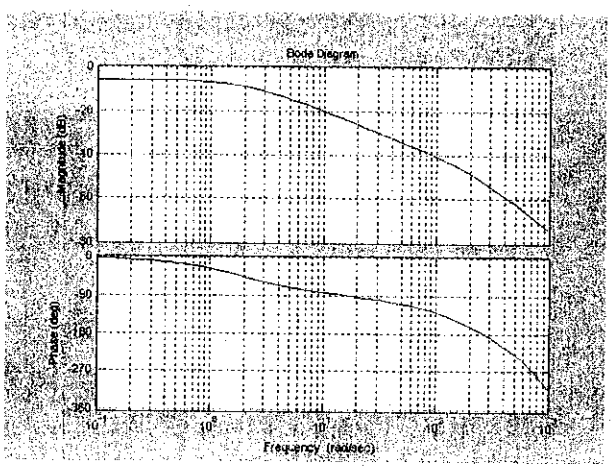

Figure 2b:




(7). (20%)Consider two dynamic systems, whose Bode diagrams are shown below. Please "guess" the possible transfer functions of the systems.

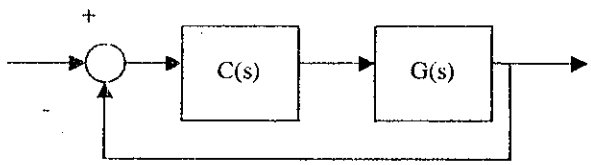



(a) Bode diagram of system A




(b) Bode diagram of system B

(8). (10%)Consider a unit feedback control system as shown below. It is desired that the closed-loop control system can have a satisfactory performance on stability and bandwidth. Please draw a proper polar plot of $G(j\omega)C(j\omega)$ that may achieve the goals. Discuss your reasons of selecting such a polar plot.

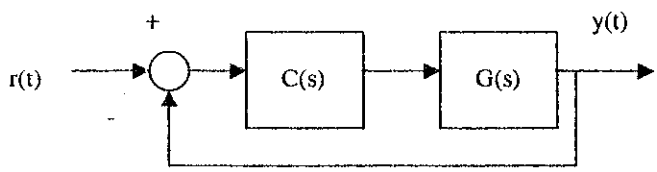



A unit feedback control system

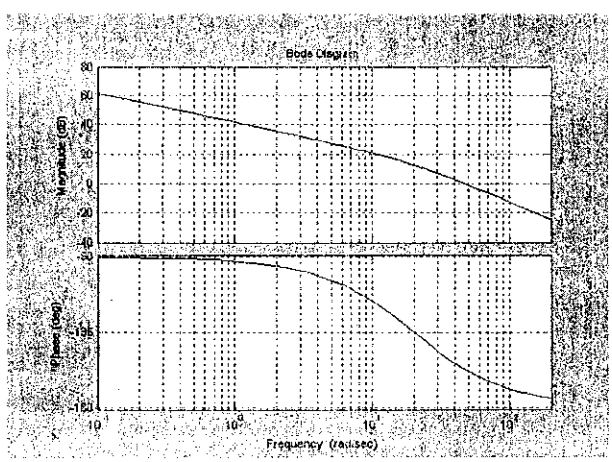
(9). (20%)Consider a unit feedback control system as shown below. The Bode diagram of G(s) is also indicated below. Now, it is desired that the output y(t) of the closed-loop control system can follow the reference input r(t) as close as possible. Assume the reference input has a form of

$$r(t) = 10 + 20\cos(10t) - 15\sin(24t) + 5\cos(36t + 2).$$

Please design a proper controller C(s) that the desired goal can be obtained. Discuss your design in detail.




A unit feedback control system




Bode diagram of G(s)

**Prob. #1 (20%)**

The tube has a length of 2 m and is made of an elastic-plastic material as shown in Figure 1. Determine the torque needed to just cause the material to become fully plastic. What is the permanent angle of twist of the tube when this torque is removed?

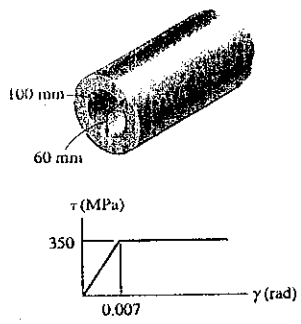



Figure 1

**Prob. #2 (15%)**

The strut has a square cross section $a$ by $a$ and is subjected to the bending moment **M** applied at an angle $\theta$ as shown in Figure 2. Determine the maximum bending stress in terms of $a$, M, and $\theta$. What angle $\theta$ will give the largest bending stress in the strut? Specify the orientation of the neutral axis for this case.

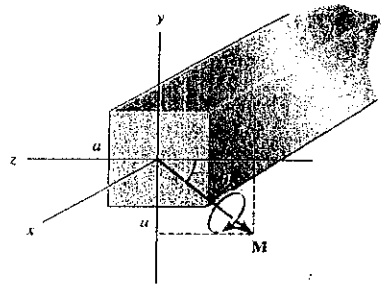



Figure 2

**Prob. #3 (15%)**

The member shown in Figure 3 is subjected to a shear force of V=2 kN. Determine the maximum shear flow in the member. All segments of the cross section are 15 mm thick.

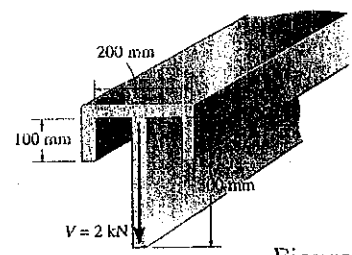



Figure 3

**Prob. #4 (25%)**

Determine the reactions at the supports $A$ and $B$ as shown in Figure 4. $EI$ is constant.

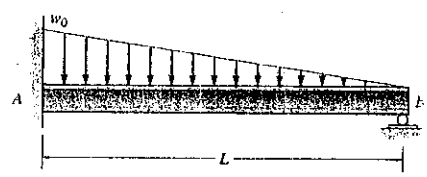



Figure 4

**Prob. #5 (25%)**

The state of stress at a point is shown on the element (Figure 5). Determine (a) the principal stresses and (b) the maximum in-plane shear stress and average normal stress at the point. Specify the orientation of the element in each case.

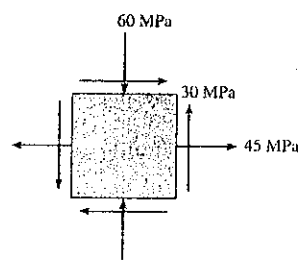



Figure 5

1. (a) As shown in Figure 1, there are two homogeneous cylinders. Each weight is 500N. Determine the minimum force F to keep the system motionless? The coefficient of friction ( $\mu$ ) is 0.2 at all contact surfaces. (15%)

   (b) Following the question (a), determine the minimum force F to push both cylinders up the inclined plane? (15%)

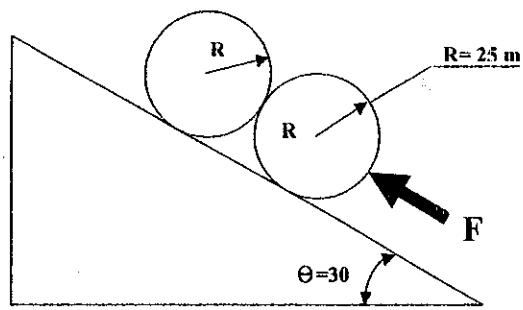



Figure 1

2. The homogenous plate (CDOH, 26mx30m in area) as shown in Figure 2 has a weight of 100N and is supported at A and B by weightless hinges and a cable CE. (a)Determine the internal force of cable CE? (Please answer the internal force in Cartesian vector : **i**, **j**, **k**, where **i** is unit vector of X direction, **j** is unit vector of Y direction, and **k** is unit vector of Z direction. ) (20%)

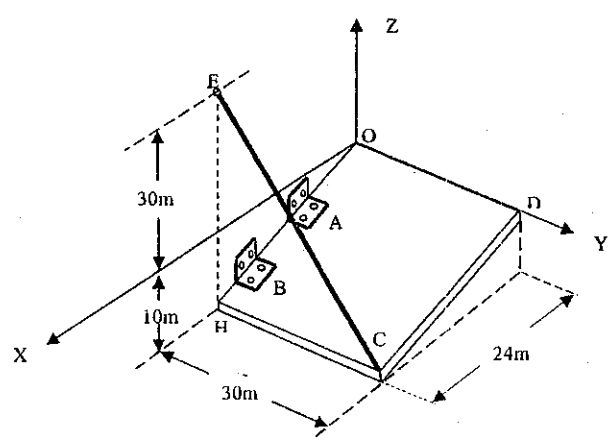



Figure 2

3. The space truss shown in Figure 3 models an airplane's landing gear. It has ball and socket supports at C, D, and E. If the force exerted at A by wheel is $\mathbf{F} = 40\mathbf{j}$ (kN), what are the axial forces in members AB, AC, and AD?(20%)

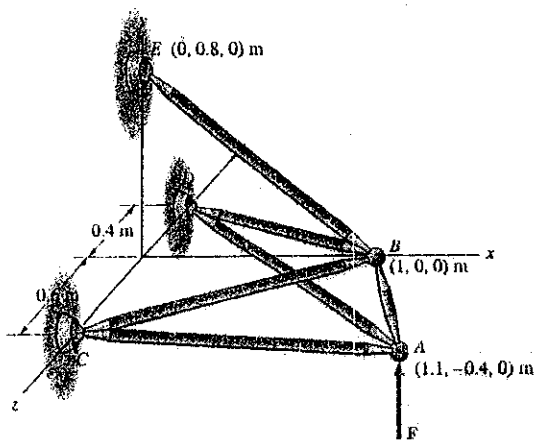



Figure 3

4. As shown in Figure 4, bar AB is connected to bar BD by a pin that fits in the smooth vertical slot. The masses of the bars are negligible. If $\mathbf{M}_A = 30$ N-m, what couple $\mathbf{M}_B$ is necessary for the system to be in equilibrium? (20%)

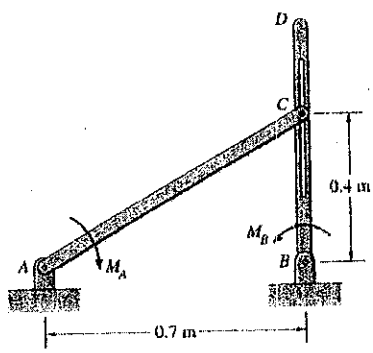



Figure 4

5. (a) What is two-force members? (5%)

(b) What is a wrench? (5%)

# 國立中山大學九十三學年度碩士班招生考試試題

科目：動力學 【機械與機電工程學系碩士班 丁組】



一、簡答題

(1) Generally, in sequence, the analysis of a vibrating system involves four steps:
(a) _____, derivation of the governing equations,
(b) _____, (c) _____. (9%)

(2) In dynamic systems, three common types of damping are (a) _____,
(b) _____, and Hysteretic damping. The logarithmic decrement represents the rate at which the amplitude of a free-damped vibration decreases. By measuring two consecutive displacement responses, the logarithmic decrement can be used to calculate the (c) _____ of a free-damped system. (9%)

(3) An automobile is found to have a natural frequency of 20 *rad/sec* without passengers and 17.32 *rad/sec* with passengers of mass 500 *kg*. By treating the automobile as a single degree of freedom system, its mass is (a) _____ *kg*, and its stiffness is (b) _____ *N*/m. (6%)

(4) Referring to Fig. 1, three springs and a mass are attached to a rigid, weightless bar *PQ*. The overall equivalent spring constant at point *Q* is (a) _____, and the natural frequency of the system is (b) _____. (6%)

二、計算題

(5) Referring to Fig. 2, show the derivation of the equation of motion based on the following methods (a) Newton's second law of motion, (b) D'Alembert's principle, (c) principle of virtual work, (d) principle of conservation of energy, (e). Lagrange's approach (20%)

(6) The four joints, *A, B, C, D*, of a spatial four bar mechanism are described as follows. Joint *A* is a spherical joint, located at (50, 100, 100) of the 3-D Cartesian coordinate system. Joint *B* is also spherical, located at the origin. Joint *C* is a revolute joint, which is at (0, 0, 100) and has an axis in the y-direction. The last joint, *D*, is also a revolute one, located at (100, 100, 100) and having an axis in the z-direction. The link *CD* is the ground link, and link *CB* rotates with a constant angular velocity of 6 *rad/sec*. (a) Find the angular velocity of link *DA* and the angular velocity of link *AB*. (b) What about the angular acceleration of link *DA*? (21%)

(7) Two identical and uniform links are placed in the vertical plane and jointed at one of their ends for free rotation. The other ends of the links are both constrained to move along a horizontal line. Now some force is applied to the assembly and causes the links to move to the right with a horizontal acceleration $a$. Determine the steady-state angle $\theta$ made by the links with each other. (15%)

(8) Imagine a planetary gear train, which consists of a sun gear, a planet gear, a carrier joining the two axes of the gears, and a ring gear. The sun gear and the planet gear are of the same size. The carrier rotates clockwise at a speed of 90 *rev/min*. Now determine the speed of the sun gear if (a) the ring gear is fixed and (b) the ring gear rotates counterclockwise with a speed of 80 *rev/min*. (14%)

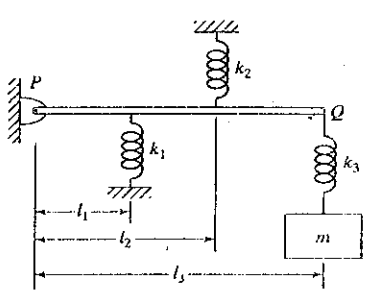



Fig. 1

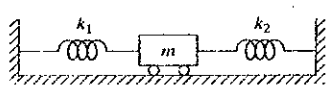



Fig. 2