(橫書式) 國立中山大學八十五學年度碩博士班招生考試試題

科 目：熱力及熱傳導、熱輻射學(机械所) 共 2 頁 第 1 頁

1. Explain the Kelvin-Planck Statement and the Clausius Statement And,

Compare the differences between the first law and second law of Thermodynamics and explain the similarities and differences of 10,000 kcal of heat at 150 C and 10,000 kcal of heat at 50 C.

(20%)

2. Define the (1) Wet bulb temperature, (2) Adiabatic Saturation Temperature, (3) Dry Bulb Temperature, (4) Humidity Ratio , (5) Relative Humidity

And, compare the differences among (1), (2), and (3)
compare the differences between (4) and (5)
derive the relationship between (4) and (5)

(20%)

3. Derive the four Maxwell Relations relating the properties P, V, T, and S.
Explain briefly why we need these relaships. (tion)

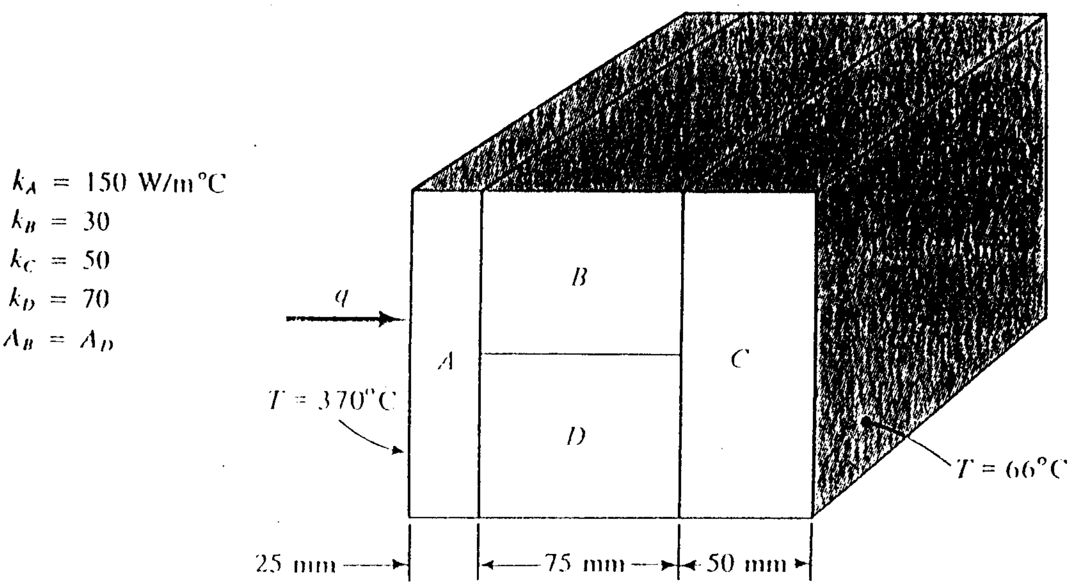
(10%)

4. Consider a wall heated by convection on one side and cooled by convection on the other side. Show that the heat-transfer rate through the wall is

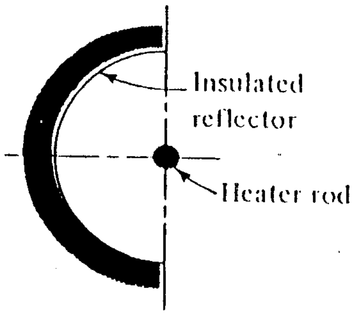
$$q = \frac{T_1 - T_2}{1/h_1A + \Delta x/kA + 1/h_2A}$$

where $T_1$ and $T_2$ are the fluid temperatures on each side of the wall and $h_1$ and $h_2$ are the corresponding heat-transfer coefficients. (15%)

5. Find the heat transfer per unit area through the composite wall sketched. Assume one-dimensional heat flow. (20%)



6. A long rod heater with $\epsilon = 0.8$ is maintained at 980°C and is placed near a half-cylinder reflector as shown. The diameter of the rod is 75 mm, and the diameter of the reflector is 0.5 m. The reflector is insulated, and the combined heater reflector is placed in a large room whose walls are maintained at 15°C. Calculate the radiant heat loss per unit length of the heater rod. How does this compare with the energy which would be radiated by the rod if it were used without the reflector? (15%)



8%

1.
(a) Explain the physical meaning of each term on the right hand side of the momentum equation

$$\rho \frac{d\vec{V}}{dt} = -\nabla p + \rho \vec{g} + \mu \nabla^2 \vec{v}$$

(b) Any assumptions have been used in deriving the momentum equation in (a)

12%

2. Consider the 2-D velocity field

$$\vec{v} = (2x + 4y)\vec{i} + By\vec{j}$$

where B is a constant

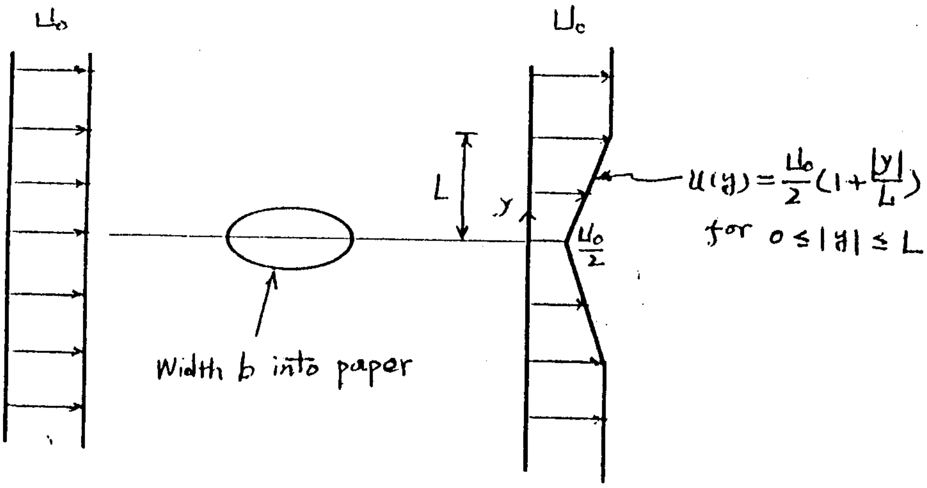
Assume that the density is constant, and the fluid is newtonian with constant viscosity coefficient $\mu$.

(a) Can the constant B be arbitrary? If not, find its value.
(b) Is the flow irrotational? If not, give the vorticity
(c) Determine the shear stress
(d) Use the stream function to sketch qualitatively the flow pattern for $x>0$

9%

3. When immersed in a uniform stream, a thick cylinder will create a broad, low velocity wake indicative of a large drag force in the downstream direction. An idealization of the flow pattern is shown in the following figure. If the pressure are equal at the inlet and outlet sections, estimate the drag force F in terms of $U_o$, $\rho$, L, and width of the cylinder. Compute the drag coefficient which is defined as

$$C_D = \frac{F}{\frac{1}{2}\rho U_o^2 bL}$$



18% 4. Consider the steady laminar incompressible flow between two parallel plates as shown in the diagram. The upper plate moves at velocity Uo to the right and the lower plate is stationary. The pressure gradient is zero. The lower half of the region between the plates ($0 \le y \le h/2$) is filled with fluid with density $\rho_1$ and viscosity $\mu_1$, and the upper half ($h/2 \le y \le h$) is filled with fluid with density $\rho_2$ and viscosity $\mu_2$.

(a) Write down the governing equations for $U_1$ and $U_2$ in this problem

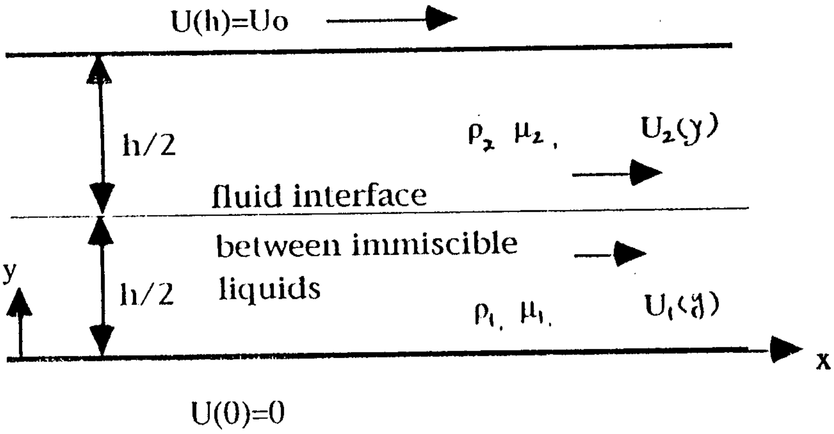
(b) What are the boundary conditions of $U_1$ and $U_2$ ?

(c) Solve for $U_1$ and $U_2$

(d) Compare the cases $\mu_1 > \mu_2$ and $\mu_2 > \mu_1$ by means of sketch of the velocity for $0 \le y \le h$.

(e) Find the shear stress on the lower wall.

(f) In the above questions, we have assumed laminar velocity profile, however, the velocity profile may become turbulent if the flow condition is changed. What is the nondimensional parameter to determine if the velocity profile is laminar or tubulent




9% 5. The drag force (resistance) of a surface ship arises from skin friction on the hull (viscous forces) and surface wave resistance (gravity forces). Consider the drag force, D, of a surface ship is a function of L, μ, ρ, g, and V. That is D=f(L, μ, ρ, g, V)

where L is the characteristic length of the ship
μ, and ρ are the viscosity and density of the water
g is the gravitational constant
V is the velocity of the ship relative to the water

(a) What are the basic dimensions in this problem?

(b) If we want to measure the drag force, $D_m$, on a small, geometrical similar model to estimate the drag force D. What dimensionless groups must be duplicated between model and prototype for complete dynamic similarity.

(c) In practical, it is very difficult to achieve dynamic similarity. Fortunately, the skin friction can be estimated analytically. To predict the wave resistance experimentally, what is the model velocity $v_m$? If we use water as the model fluid, L=50m, V=5m/sec, and the length of the model $L_m$=50cm

9% 6 Consider the irrotational flow made up from a uniform stream of velocity U over a circular cylinder of radius a, about which there is a circular Γ.
(a) Find the stagnation points as a function of Γ, a, and U. Sketch some streamlines.
(b) Find the direction and the magnitude of the lift on the cylinder.
(c) In a few words, state how this related to flows over bodies

7. Consider water in parallel flow over an isothermal, 1-m-long, flat plate with a velocity of 2 m/s. $Nu_x = 0.332\ Re^a\ Pr^b$ for laminar flow and $Nu_x = 0.0296\ Re^c\ Pr^d$ for turbulent flow.

5% (1) What are the values for a, b, c and d?

10% (2) Assume critical Reynolds number $Re_{x,c}=5\times10^5$, calculate the local heat transfer coefficient, $h_x$, at x = 0.1, 0.2, 0.4 and 0.6 m.
($\rho$ =1000 kg/m$^3$, $\mu$=860×10$^{-6}$ N s/m$^2$, k =0.61 W/m K, $C_p$=4.186 kJ/kg K)

10% 8. Water flowing at 2 kg/s through a 40-mm-diameter tube is to be heated from 25 to 75°C by maintaining the tube surface temperature at 100 °C. What is the required tube length? ($\overline{Nu}$ = 3.66 for laminar flow and $\overline{Nu} = 0.023\ Re_D^{0.8}Pr^{0.4}$ for turbulent flow. For water at 50 °C, $C_p$ = 4.18 kJ/kg K, $\mu$ = 550×10$^{-6}$ N s/m$^2$, k = 0.643 W/m K and $\rho$ =990 kg/m$^3$.)

10% 9. Define each of the following numbers, and state their physical interpretation.
(1) Reynolds number, Re
(2) Nusselt number, Nu
(3) Peclet number, Pe
(4) Prandtl number, Pr
(5) Grashof number, Gr

1. A particle moves in space in such a way that $r = 5t^2$, $\phi = 2\pi t$, $z = 3t$, where $r$ and $z$ are in meter, $\phi$ is in radians, and $t$ is the time in seconds. Determine the velocity and acceleration at any time $t$. (15%)

2. In the system shown as below, the left end of spring $k_1$ and the right end of spring $k_2$ are given motions $x_1 = X_1 \cos \omega t$ and $x_2 = X_2 \cos \omega t$, respectively. (a) Derive the equation of motion of mass $m$, and (b) solve for the steady-state motion. (15%)

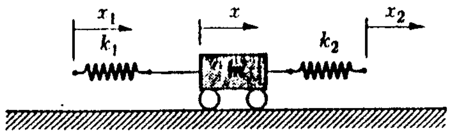



Fig. 2

3. Show the relationship between the flexibility and the stiffness matrices for the two-spring system shown in Fig. 3. The externally applied forces are $P_1$ and $P_2$, and the linearly elastic flexibilities and stiffnesses for each spring are shown in the figure. (20%)

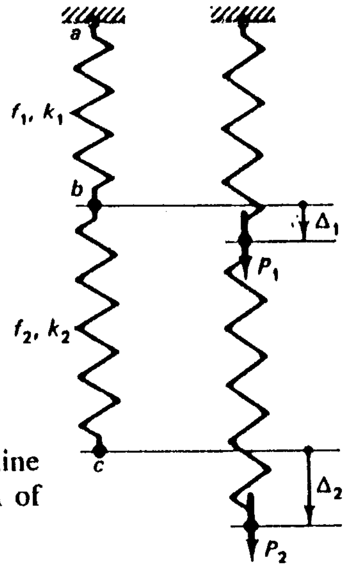



Fig. 3

4. For the planar system of the three elastic bars shown in Fig. 4, determine the forces in the bars caused by applied force $P$. The cross-sectional area $A$ of each bar is the same, and their elastic modulus is $E$. (20%)

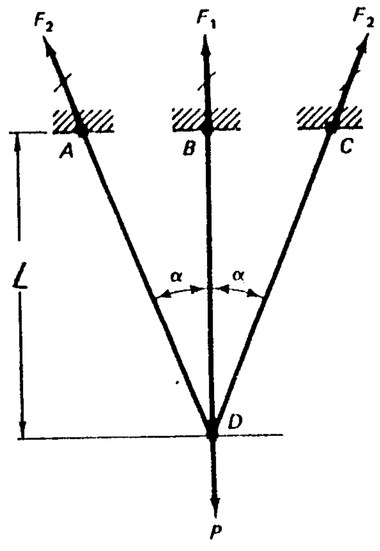



Fig. 4

5. The uniform slender pole as shown has a mass of 100 Kg and a moment of inertia $I_G$ = 75 Kg.m². If the coefficient of static and kinetic friction between the end of the pole and the surface are 0.3 and 0.25, respectively, determine the pole's angular acceleration at the instant the 400-N force is applied. The pole is originally at rest. (15%)

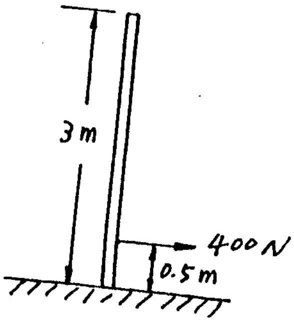



Fig. 5

6. The wheel weighs 40 lb and has a radius of gyration $k_G$ = 0.6 ft about its mass center G. If it is subjected to a clockwise couple moment of 15 lb.ft and rolls from rest without slipping, determine its angular velocity after its center G moves 0.5 ft. The spring has a stiffness k = 10 lb/ft and is initially unstretched when the couple is applied. (15%)

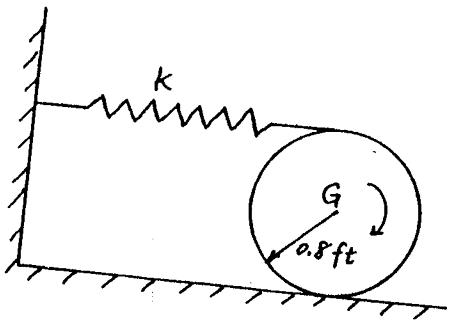



Fig. 6

1. (15%) The operational amplifier is one of the most important circuit elements. It is small and versatile. It can be used to build buffers, amplifiers, error detectors, and compensating networks, and is therefore widely used in control systems. The operational amplifier is usually represented as shown in Figure 1 and is modeled as shown in Figure 2. It has two input terminals. The one with a "-" sign is called the inverting terminal and the one with a "+" sign the non-inverting terminal. The output voltage equals $A(v_i - v_{i1})$, and $A$ is called the open-loop gain. The resistor $R_i$ in Figure 2 is called the input resistance and $R_o$, the output resistance. In practice, $R_i$ is usually very large and $R_o$ is very small. With an addition of resistor $R_2$ as the negative feedback, determine the close-loop gain from input voltage $V_I$ to output voltage $V_o$ of Figure 3.

2. (5%) It is well known that the most ideal phase response has zero phase error over the working frequency range. However, this is not always possible. Therefore, an alternative design is to make phase response varies linearly with the frequency in the operating frequency interval. Explain the motivation behind this design strategy.

3. (10%) This problem considers the frequency response of a system whose transfer function is

$$G(s) = \frac{1}{(s/\omega_n)^2 + 2\zeta(s/\omega_n) + 1}$$

The magnitude and phase responses for $\zeta = 0.3$ and $\zeta = 0.7$, are given in Figures 4 and 5, respectively. In Figure 5, indicate which curve corresponds to $\zeta = 0.3$. Explain why?

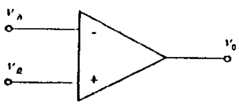



Fig. 1

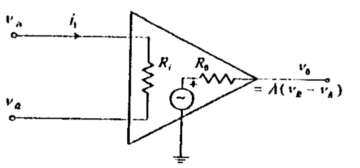



Fig. 2

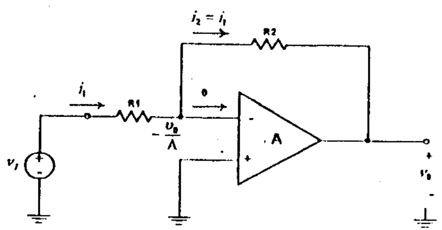



Fig. 3

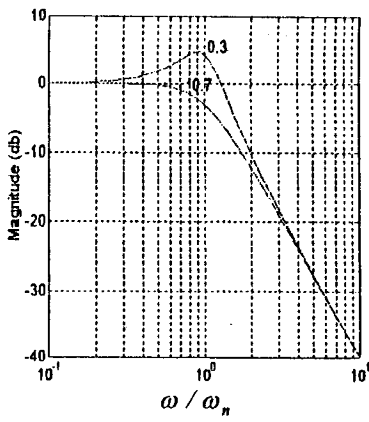



Fig. 4

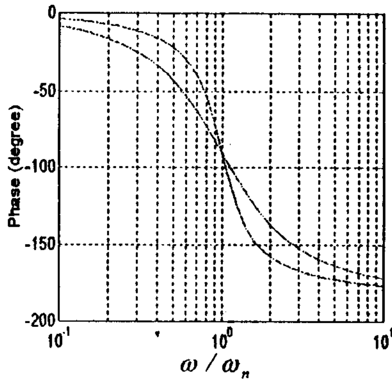
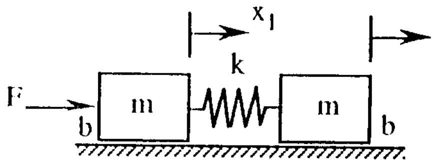



Fig. 5

4. A plant is modeled as two identical masses linked with an elastic spring shown below, where b represents the damping coefficient and F is the exerted force.




Dynamic equations for the system are easily obtained as follows:

$$F - k(x_1 - x_2) = m\ddot{x}_1 + b\dot{x}_1$$

$$k(x_1 - x_2) = m\ddot{x}_2 + b\dot{x}_2$$

Besides, F can be formulated in terms of the input voltage V, i.e.,

$$F = p(V - q x_1)$$

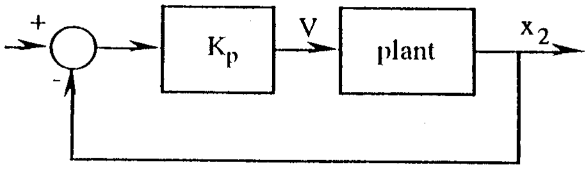
(1) Draw a block diagram for the system with the input V and the output $x_2$ based on the above equations. (10%)

(2) Determine the input-to-output transfer function. (10%)

To simplify the analysis, we assume that

$$m = k = p = 1 \quad \text{and} \quad b = q = 2$$

A proportional controller $K_p$ is applied to construct a closed-loop control system.




(3) Sketch the root loci for the system ( $0 < K_p < \infty$ ). (10%)

(4) Solve the steady state error for a unit step command when $K_p = 10$. (5%)

5. Consider a time-invariant plant, which can be a linear or nonlinear dynamic system, to be controlled. Because of its complexity, the mathematical model of this plant can not be accurately derived through an analytical process. Under such a circumstance, what kind of approach or method will you take to design a control system for this plant? Please discuss your approach or method as much as you can. (20%)

6. Draw the polar plot of an open-loop transfer function that its closed loop response is desirable. Please discuss the advantages of such an open-loop polar plot in details. (15%)

1) Answer these questions concisely (30%)

a) Define planar motion of a rigid body.

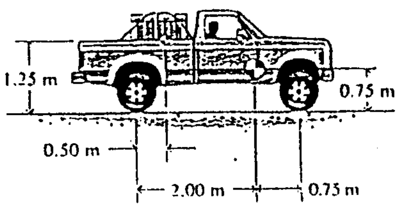
b) List the differences between rigid-body dynamics and particle dynamics.

c) What is instant axis of rotation of a rigid body?

2) 20% The small rear-wheel drive truck shown has a mass of 1750 kg and is carrying a 400 kg load. The center of mass of the truck is 0.75 m behind the front axle; the center of mass of the crate is 0.5 m in front of the rear axle. If the static coefficient of friction between the pavement and the tires is 0.85 and the crate is securely tied down,
Determine the minimum time required for the truck:

a) ______________ seconds
To accelerate uniformly from rest to 90 km/h.

b) ______________ seconds
To decelerate uniformly from 90 km/h to rest.




3) 20% Two 400-mm diameter disks and a 240 mm diameter diameter disk are jointed to form a spool that has a mass of 125 kg and a radius of gyration of 125 mm with respect to an axis through the mass center of the spool. A force F of 500 N is applied to the spool through a cable wrapped around the 240 mm disk shown. Determine the acceleration of the mass center and the angular acceleration of the spool

a) If the horizontal surface is smooth ( coefficient of friction = 0)

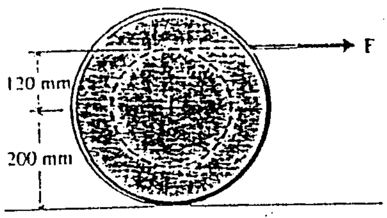
the acceleration of the mass center = ______________________

angular acceleration of the spool= ______________________

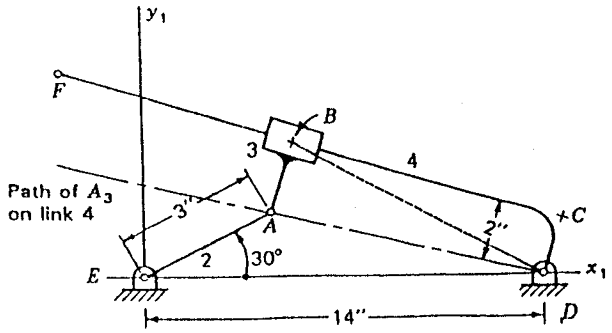
b) If the horizontal surface is rough ( coefficient of friction = 0.25)

the acceleration of the mass center = ______________________

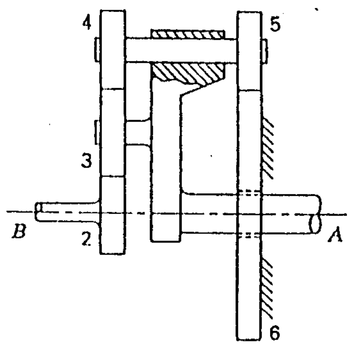
angular acceleration of the spool= ______________________



4) The figure below shows an inversion of the slider-crank mechanism. Link 2 is driven at an angular velocity of 36 rad/s clockwise. Link 3 slides on link 4 and is pivoted to the crank at A. Determine the angular velocity and angular acceleration of link 4. (18%)




5) In the figure shaft A is the output and is connected to the arm. If shaft B is the input and drives gear 2, what is the speed ratio of the input and the output. (12%)




$N_2 = 16T,\ N_3 = 18T,\ N_4 = 16T,\ N_5 = 18T,\ N_6 = 50T.$

机械所 J組

(橫書式)

# 國立中山大學 八十五 學年度碩士班招生考試試題

科　目：靜力學



1. The figure shows a series of rectangular plates and their constraints, all confined to the plane of representation. The plates could be subjected to various known loads applied in the plane of the plates. Identify the plates that belong to each of the following categories:

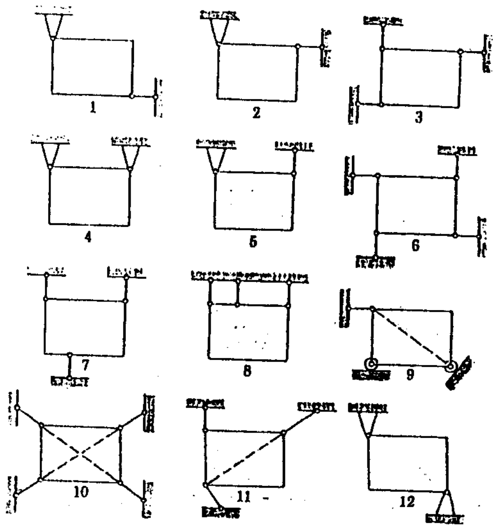
   (a) Complete fixity with minimum number of adequate constraints (4%)

   (b) Partial fixity with inadequate constraints (4%)

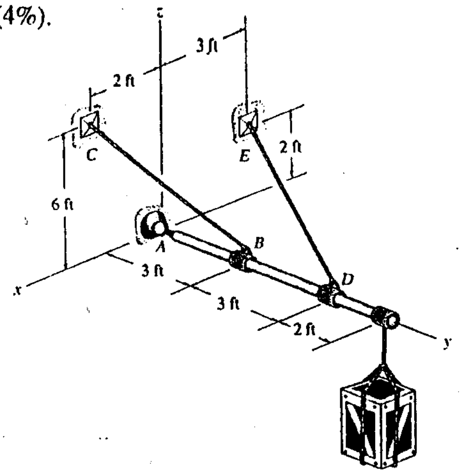
   (c) Complete fixity with redundant constraints (4%)

   (d) Partial fixity with redundant constraints (4%)

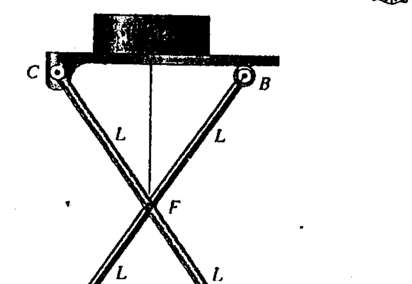
   Note: Your answers must be completed to earn full credit. Some situations may be categorized in more than one category.




2. The boom supports a load having a weight of W= 850 lb. Determine the $x$, $y$, $z$ components of reaction at the ball-and-socket joint $A$ (6%) and the tension in cables BC (4%) and DE (4%).




3. The weight $W$ is placed on the table such that its center of gravity $G$ is directly over the pin at $F$. Determine the compressive force in the hydraulic cylinder DE in terms of $W$ and the geometry of the platform. Each member has a length $2L$ and in pinned at its center. (15%).



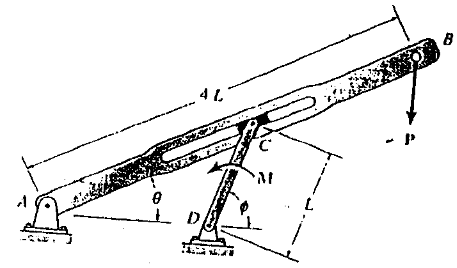
(橫書式)

國立中山大學八十五學年度碩士班招生考試試題

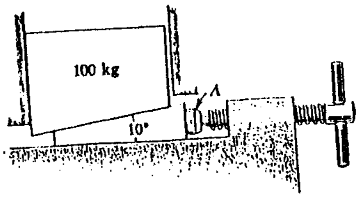
科目：靜力學



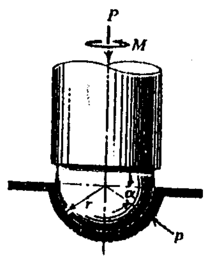
4. Determine the couple moment M that must be applied to member DC for equilibrium of the quick-return mechanism. Express the result in terms of the angle $\phi$ and $\theta$, dimension $L$, and the applied vertical load $P$. The block at C is confined to slide within the slot of member AB. (15%)



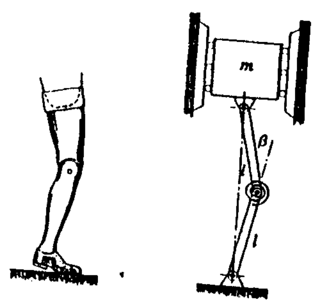

5. THe vertical position of the 100-kg block is adjusted by the screw-activated wedge. Calculate the moment M which must be applied to the handle of the screw to raise the block. The single-threaded screw has square threads with a mean diameter of 30 mm and advances 10 mm for each complete turn. The coefficient of friction for the screw threads is 0.10, and the coefficient of friction for all mating surfaces of the block and wedge is 0.40. Neglect friction at the ball joint A. (20%)




6. The spherical thrust bearing on the end of the shaft supports an axial load P. Determine the expression for the moment M required to turn the shaft against friction in the bearing. Assume that the pressure p is directly proportional to sin$\alpha$ and that the coefficient of friction is $\mu$. (10%)

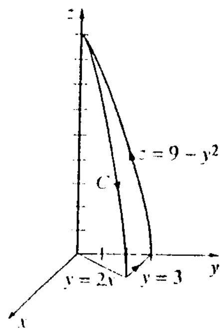



7. One of the critical requirements in the design of an artificial leg for an amputee is to prevent the knee joint from buckling under load when the leg is straight. As a first approximation, simulate the artificial leg by the two light links with a torsion spring at their common joint. The spring develops a torque $M=K\beta$, which is proportional to the angle of bend $\beta$ at the joint. Determine the minimum value of K that will ensure stability of the knee joint for $\beta=0$. (10%)



〔 V 〕 Use Stoke's theorem to evaluate $\oint_c \mathbf{F} \bullet d\mathbf{r}$

Assume C is oriented counterclockwise as viewed from above. Where $\mathbf{F} = x^2 y\mathbf{i} + (x + y^2)\mathbf{j} + xy^2 z\mathbf{k}$ ; C the boundary of the surface shown in figure (8 %)




〔 VI 〕 To select the proper answers in following problems.
Note: The answers for each problem may be more than one.

(1) Let Z be the complex variable, then $\left| Z/(Z-1) \right| = 2$ represents (12%)

(a) a circle with radius equals 2/3.
(b) a circle with center at ( 0, 4/3 )
(c) a circle with radius eauals 4/3 and center at ( 0,4/3 )
(d) a circle with radius eauals 2/3 and center at ( 4/3, 0 )
(e) All the above four statements are incorrect

(2)Let $\nabla$ represents a vector operator of the form

$$\nabla = \vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}$$

Also, let **U**,**V** be two arbitrary vector functions and A,B be two arbitrary scalar functions, then which statements below are correct? (13% )

(a) $\nabla \cdot (\mathbf{U} \times \mathbf{V}) = \mathbf{V} \cdot (\nabla \times \mathbf{U}) - \mathbf{U} \cdot (\nabla \times \mathbf{V})$
(b) $\nabla \cdot (\nabla \times \mathbf{U}) = 0$
(c) $\nabla \times (\nabla \times \mathbf{A}) = 0$
(d) $\nabla \cdot (\nabla A \times \nabla B) = 0$
(e) All the above four statements are incorrrect.