I. 選擇題部分 (單選題) (每題 4 分，共計 48 分)

1. Evaluate $\int_C \mathbf{F} \bullet d\mathbf{R}$ if $\mathbf{F} = x\mathbf{i} - y\mathbf{j} + z\mathbf{k}$ and C is the straight line segment from (1, 1, 1) to (-2, 1, 3). Which of the following is the value of the line integral? (A) 0, (B) 1/2, (C) 1, (D) 2, (E) none of the above.

2. In the complex plane, evaluate $\frac{1}{2\pi i}\oint_C [z - \mathrm{Re}(z)]$ on the circle C: $|z| = 2$. The closed curve C is oriented counterclockwise. Which of the following is the value of the integral? (A) -2, (B) -1, (C) 1, (D) 2, (E) none of the above.

3. The residue at the singular point of the complex function $f(z) = \frac{1 - \cos z}{z^3}$ is (A) 1, (B) 1/2, (C) -1/24, (D) 1/720, (E) none of the above.

Problems (4) – (6): The term $P(X)$ represents the probability of event X. The conditional probability of A under the condition that an event B occurs is denoted by $P(A \mid B) = \frac{P(A \cap B)}{P(B)}$. The probability of the complement $\overline{A}$ is $P(\overline{A}) = 1 - P(A)$.

4. If $P(A) = 0.80$, $P(B) = 0.70$ and $P(A \text{ or } B) = 0.90$, then $P(A \text{ and } B)$ is (A) 0.10, (B) 0.14, (C) 0.60, (D) 0.72

5. Suppose A and B are events of a sample space S with $P(A) = 0.22$, $P(B) = 0.40$, and $P(A \text{ and } B) = 0.04$, then $P(A \mid \overline{B})$ is (A) 0.462, (B) 0.300, (C) 0.182, (D) 0.100

6. If $P(A) = 0.45$, $P(B) = 0.35$ and $P(A \text{ and } B) = 0.25$, then $P(A \mid B)$ is (A) 1.4, (B) 1.8, (C) 0.714, (D) 0.556.

Problems (7) – (12): For the 3×3 matrix

$$A = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 4 & 3 \\ 0 & 3 & -4 \end{bmatrix}$$

7. The smallest eigenvalue is (A) -6, (B) -5, (C) -2, (D) 2, (E) 4.
8. The sum of all the eigenvalues is (A) 0, (B) 1, (C) 2, (D) 3, (E) 4.
9. The product of all the eigenvalues is (A) 24, (B) -50, (C) -36, (D) 60, (E) 48.
10. Determinant of A is (A) 24 (B) -50 (C) -36 (D) 60 (E) 48.
11. Which of the following statements is true? (A) A is positively definite. (B) Eigenvectors of A can be mutual orthogonal. (C) Only two of the eigenvectors are orthogonal. (D) Ax = b for arbitrary b, then there is no unique solution. (E) A is not invertible.
12. Which of the following statements is true? (A) AB = BA for arbitrary matrix B. (B) There can be a nonzero matrix B such that AB = [0]. (C) If AB = AC, then B = C for arbitrary matrices B and C. (D) Eigenvectors of A are not linearly independent. (E) A is not a Hermitian matrix.

II. 選擇題部分(單選題) (七題共計 25 分)

13. (3%) The condition for the exactness of the first-order ordinary differential equation $Mdx + Ndy = 0$ is (A) $\partial M/\partial x = \partial N/\partial y$, (B) $\partial M/\partial x = \partial M/\partial y$, (C) $\partial M/\partial y = \partial N/\partial x$, (D) $\partial^2 N/\partial x\partial y = \partial^2 M/\partial y\partial x$.

14. (3%) Two solutions of a second-order linear ordinary differential equation are independent if the Wronskian (A) W = 0, (B) W > 0, (C) $W \neq 0$, (D) W < 0.

15. (3%) The general solution of a nonhomogeneous linear differential equation is (A) $y = y_h$, (B) $y = y_p$, (C) $y = y_h + y_p$, (D) $y = y_h y_p$, where y_h and y_p are, respectively, the homogeneous and particular solutions.

16. (3%) A curve in a space cannot be described by (A) $\mathbf{r} = x(t)\mathbf{i} + y(t)\mathbf{j} + z(t)\mathbf{k}$, (B) F(x,y,z)=0 and G(x,y,z)=0, (C) F(x(t),y(t),z(t))=0, (D) z = f(x), y = g(x).

17. (3%) The directional derivative df/ds, where $ds = \|d\mathbf{r}\|$, is (A) $\partial f/\partial s$, (B) $\mathbf{dr}/ds \times \nabla f$, (C) $\nabla f \bullet \mathbf{dr}/ds$, (D) $\nabla \bullet \mathbf{fr}$.

18. (5%) The general solution of $y' + p(x)y = r(x)$ is (A) $y = \exp(-\int pdx)[\int \exp(-\int pdx) rdx + c]$, (B) $y = \exp(\int pdx)\int \exp(-\int pdx) rdx + c$, (C) $y = \exp(-\int pdx)[\int \exp(\int pdx) rdx + c]$, (D) None.

19. (5%) Find the arc length of a helix $\mathbf{r} = \cos t\,\mathbf{i} + \sin t\,\mathbf{j} + ct\,\mathbf{k}$, where c is a constant. (A) $s = \sqrt{1+ct}$, (B) $s = t^2\sqrt{1+c^2}$, (C) $s = t\sqrt{1+c^2}$, (D) None.

III. 計算題部分 (三題共計 27 分)

1. (14%) The complex exponential Fourier representation of a signal $f(t)$ over the interval $(0, T)$ is

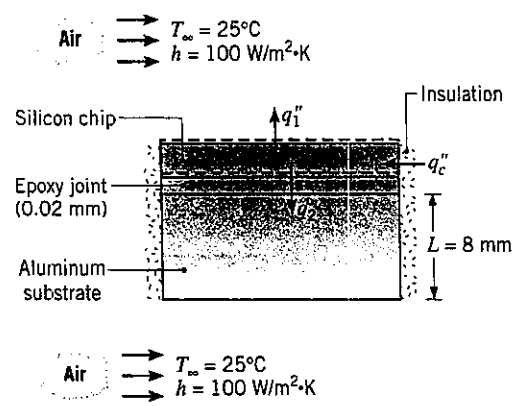
$$f(t) = \sum_{n=-\infty}^{\infty} \frac{3}{4 + (n\pi)^2} e^{jn\pi t}$$

   A. What is the numerical value of T?
   B. One of the components $f(t)$ is $A\cos 3\pi t$. Determine the value of A.

2. (7%) Find the tangent plane and normal line to the surface $z = x^2 + y^2$ at (2, -2, 8).

3. (6%) Determine the Laplace transform of the function $f(t) = t\cos at$.

1. 5%. What is the corresponding cycle for an idealized steam power plant? What are the processes in this power cycle? Draw the p-v and T-s diagrams for the cycle and indicate all the processes.
2. 10%. Compare the vapor-compression refrigeration cycle with an absorption refrigeration cycle by drawing the schematics for the two cycles and explaining the differences. Individually explain how you could use solar energy to drive these two refrigeration systems.
3. 10%. Please discuss the four basic laws of thermodynamics and discuss their contributions of these four laws, respectively.
4. 5%. Air is compressed from room conditions to a specified pressure in a reversible manner by two compressors: one isothermal and the other adiabatic. If the entropy change of air Δs_{isot} during the reversible isothermal compression, and Δs_{adia} during the reversible adiabatic compression, the correct statement regarding entropy change of air per unit mass is
   (a) $\Delta s_{isot}=\Delta s_{adia}=0$ (b) $\Delta s_{isot}=\Delta s_{adia}>0$ (c) $\Delta s_{adia}>0$ (d) $\Delta s_{isot}<0$ (e) $\Delta s_{isot}=0$
5. 10%. What are the differences in the ignition methods of the gasoline engine and the diesel engine? What kinds of the cycle analysis are used in these two types of the engines, respectively? Explain also the meanings of compression ratio, cutoff ratio, and pressure ratio.
6. 5%. How do we judge if a general thermodynamic system has reached its thermodynamic equilibrium?
7. 5%. If two different liquids of known volumes are mixed, is the final volume necessarily equal to the sum of the original volumes? Why?
8. 15%. Derive expressions for (a) Δu, (b) Δh, and (c) Δs for a gas that obeys the van der Waals equation of state for an isothermal process.
   Note: the van der Waals equation of state is $P=RT/(v-b)-a/v^2$.
9. 6%. How to measure the thermal conductivity of a solid?
10. 15%. A thin silicon chip and an 8-mm-thick aluminum substrate (k = 238 W/m K) are separated by a 0.02-mm-thick epoxy joint (joint thermal resistance is 0.9×10^{-4} m^2K/m). The chip and substrate are each 10 mm on a side, and their exposed surfaces are cooled by air, which is at a temperature of 25 °C and provides a convection coefficient of 100 W/m^2 K. Under normal conditions, the chip dissipates 10^4 W/m^2. The maximum allowable temperature for the chip is 85 °C? Will this chip work properly? (State all assumptions when solving the problem.)



11. 5% Define the fin effectiveness ε_f. Define the fin efficiency η_f.
12. 9% Write down the heat conduction equation for a 2-D steady uniform-conductivity problem. What are the methods for solving the problem?

1. (10%)Three velocity components of a flow field are given by

$$u = x^2 + y^2 + z^2$$
$$v = xy + yz + z^2$$
$$w = -3xz - z^2/2 + 8$$

(a) Determine the volumetric dilatation rate and interpret the results.
(b) Determine the vorticity of the flow filed. Is this an irrotational flow?

2. (10%) A two-dimensional potential flow is described by the velocity potential

$$\phi = 2x^2y - (\frac{2}{3})y^3$$

where ϕ has the units of m^2/s when x and y are in meters.
(a) Determine the pressure at the point x=2m, y=2m if the pressure at x=1m, y=1m is 200 kpa. Elevation changes can be neglected and the fluid is water with density $1000kg/m^3$.
(b) Find the stream function for the flow field and sketch streamlines

3. (5%) Given the Eulerian velocity vector field

$$\vec{V} = 3t\vec{i} + xz\vec{j} + ty^2\vec{k} \quad (m/s)$$

Find the total acceleration of a particle when it passes the location (x,y,z)=(1, 2, 3) in meters, at time t=1sec.

4. (10%) A nozzle is attached to a vertical pipe and discharges water into the atmosphere as shown in Figure 4. When the discharge is $0.1 m^3/s$, the gage pressure at the flange is 40 kPa. Determine the vertical component of the anchoring force required to hold the nozzle in place. The nozzle has a weight of 200 N, and the volume of water in the nozzle is $0.012\,m^3$. Is the anchoring force directed upward or downward?

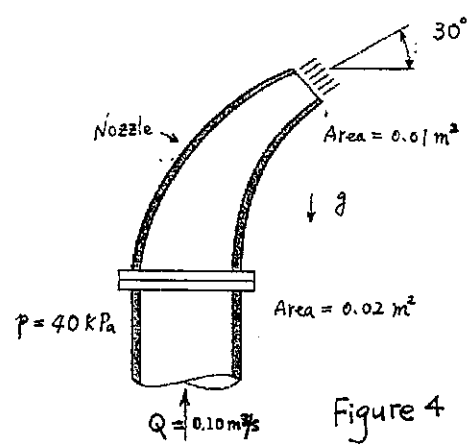


Figure 4

5. (20%) Consider a steady flow of newtonian fluid between fixed parallel plates with pressure gradient $\frac{\partial P}{\partial x}$ along the x- direction. We want to find the velocity distribution between the plates as shown in Figure 5.

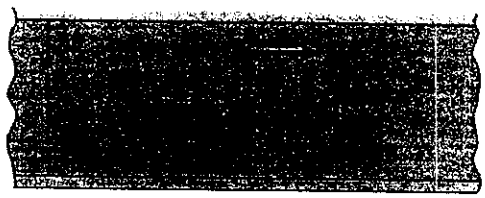


Figure 5

(a) Write the governing equations for the fluid flow.
(b) Boundary conditions?
(c) Solve for the velocity distribution u(y)= ?
(d) Calculate the volume rate of flow q per units width in the z-direction, in terms of $\frac{\partial P}{\partial x}$, h and μ (viscosity)

6. (10%) A long structural component of a bridge has the cross section shown in the figure. The cross section has length D and width H. The wind approaching the structure has velocity V, density ρ and viscosity μ. Vortex shedding is found in the wake of the structure. We expect shedding frequency ω= f (D, H, V, ρ, μ). Rewrite the functional relation in dimensionless form by applying pi-theorem.

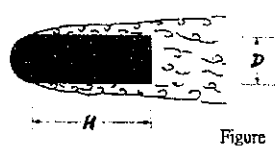
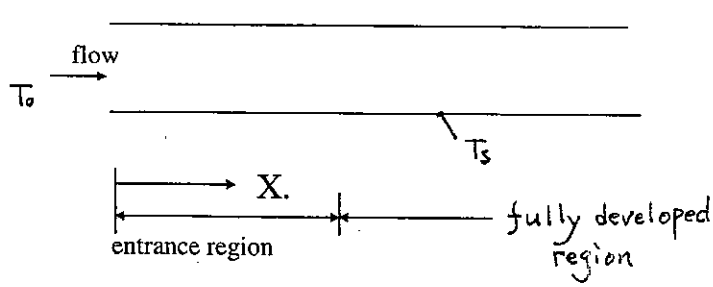


Figure 6

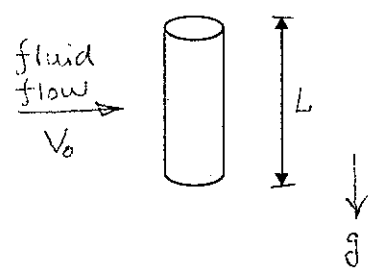
7. (10%) A hot fluid, with temperature To at X=0, flows into a tube with uniform surface temperature Ts. (To>Ts). The fluid flow in the tube is laminar, and the entrance region is shown in the figure.
(a) Sketch the distribution of local heat transfer coefficient along the tube, i.e. h_{cx} versus X
(b) Sketch the bulk temperature of the fluid as a function of X



8. (10%) Consider convective heat transfer of a vertical heated cylinder in a fluid, as shown in the figure. The cylinder with diameter D and length L has uniform surface temperature Ts. The major properties of the fluid in the problem include density ρ, kinematic viscosity ν, thermal diffusivity α, volumetric coefficient of thermal expansion β. The fluid approaches the cylinder horizontally with velocity Vo and temperature To. Gravitational acceleration is g. ($T_s > T_o$)

(a) In case that the free stream velocity is zero Vo=0, there is only natural convection. What are the two major dimensionless parameters (grouped from the above dimensional quantities) that the Nusselt number, averaged over the cylinder, depends?

(b) In case that the free stream velocity is not zero, forced convection is expected. What are the two major dimensionless parameters (grouped from the above dimensional quantities) that the Nusselt number of the forced convection depends?



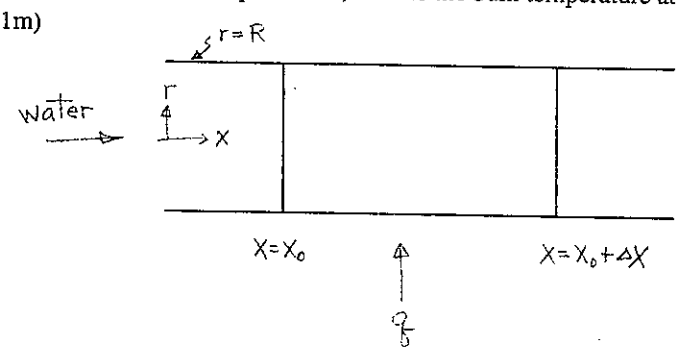
9. (15%) Water in a circular pipe has velocity distribution $u(r)/U_{max}=\{1-(r/R)^2\}$ and temperature distribution $(T-T_0)/(T_{max}-T_0)=\{1-(r/R)^2\}$, at the section $x=x_0$, where R=10cm is the radius of the pipe, U_{max}=0.2cm/s is the water velocity at the centerline(r=0), T_{max}=20℃ is water 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 $x=x_0$?

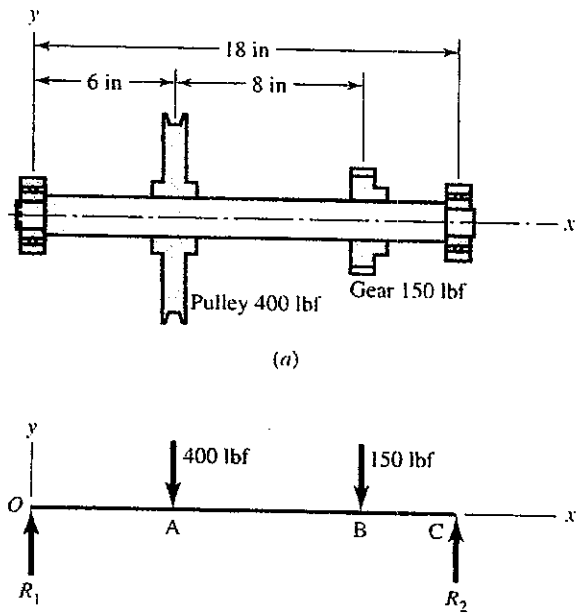
(b) What is the bulk temperature at $x=x_0$?

(a) Under a constant heating with heat flux $q=50w/m^2$, what is the bulk temperature at $x=x_0+\Delta x$? (Δx=1m)



To select the proper answer for following questions (5% for each)

(一). ***The diameter of the solid round shaft is 1.25 inch, as shown in following figure. The shaft is supported by self-aligning bearings at the ends. Mounted upon the shaft are a V-belt sheave, which contributes a radial load of 400 lbf to the shaft, and a gear, which contributes a radial load of 150 lbf. The two loads are in the same plane and have the same directions.***



1. ( ) The reaction forces at both bearings are (A) $R_1 = 250\ lbf$; $R_2 = 300\ lbf$

   (B) $R_1 = 300\ lbf$; $R_2 = 250\ lbf$ (C) $R_1 = 350\ lbf$; $R_2 = 200\ lbf$

   (D) $R_1 = 200\ lbf$; $R_2 = 350\ lbf$ (E) None

2. ( ) The shear force at the midpoint of the shaft is (A) $V = -400\ lbf$ (B) $V = -550\ lbf$

   (C) $V = -100\ lbf$ (D) $V = -250\ lbf$ (E) None

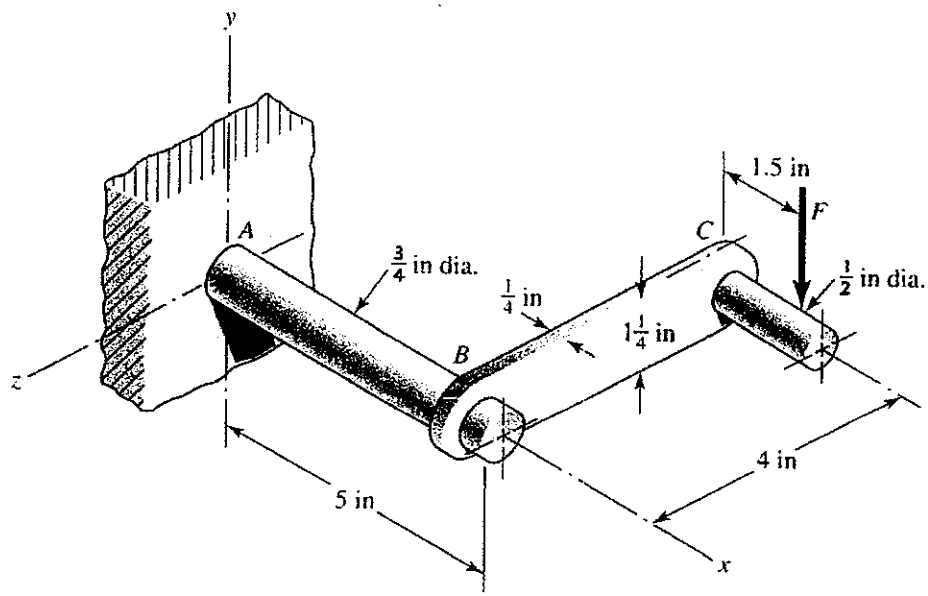
3. ( ) The maximum bending moment on the shaft is (A) $M = 1800\ lbf - in$

   (B) $M = 1000\ lbf - in$ (C) $M = 1300\ lbf - in$ (D) $M = 900\ lbf - in$ (E) None

4. ( ) The maximum bending stress on the shaft is (A) $\sigma_b = 3825\ psi$ (B) $\sigma_b = 4736\ psi$

   (C) $\sigma_b = 6513\ psi$ (D) $\sigma_b = 9387\ psi$ (E) None

（二）. ***A crank is loaded by a force*** $F = 300\ lbf$ ***that causes twisting and bending of a 3/4 inch diameter shaft fixed to a support at the origin of the reference system.***



5. ( ) The bending stress at a stress element A is (A) $\sigma_b = 19400\ psi$ (B) $\sigma_b = 47100\ psi$ (C) $\sigma_b = 68900\ psi$ (D) $\sigma_b = 94700\ psi$ (E) None

6. ( ) The torsional stress at a stress element A is (A) $\tau_{xz} = -14500\ psi$ (B) $\tau_{xz} = -44500\ psi$ (C) $\tau_{xz} = 14500\ psi$ (D) $\tau_{xz} = 44500\ psi$ (E) None

7. ( ) Point A is in a state of (A) Plane strain state in the xz plane (B) Plane stress state in the xz plane (C) Plane strain state in the xy plane (D) Plane stress state in the xy plane (E) None

8. ( ) The maximum principal stress at the point A is (A) $\sigma_1 = 3.82\ kpsi$ (B) $\sigma_1 = 47.1\ kpsi$ (C) $\sigma_1 = 51.2\ kpsi$ (D) $\sigma_1 = 93.87\ kpsi$ (E) None

9. ( ) The maximum shear stress at the point A is (A) $\tau_{max} = 2.56\ kpsi$ (B) $\tau_{max} = 4.76\ kpsi$ (C) $\tau_{max} = 11.2\ kpsi$ (D) $\tau_{max} = 27.7\ kpsi$ (E) None

（三）. ***A hot-rolled steel has a yield strength of*** $S_{yt} = S_{yc} = 100\ kpsi$. ***Estimate the factor of safety for the principal stress states of*** $\sigma_1 = 70\ kpsi$, $\sigma_2 = 30\ kpsi$, ***and*** $\sigma_3 = -30\ kpsi$.

10.( ) The factor of safety based on the maximum shear stress theory is (A) $SF = 1.13$ (B) $SF = 1.43$ (C) $SF = 1.64$ (D) $SF = \infty$ (E) None

11.( ) The factor of safety based on the maximum distortion energy theory is (A) $SF = 1.13$ (B) $SF = 1.43$ (C) $SF = 1.64$ (D) $SF = \infty$ (E) None

12.( ) The factor of safety based on the maximum normal stress theory is (A) $SF = 1.13$ (B) $SF = 1.43$ (C) $SF = 1.64$ (D) $SF = \infty$ (E) None

（四）. ***A specimen of medium-carbon steel having an initial diameter of*** $d_o = 0.503$ ***inch was tested in tension using a gauge length of*** $\ell_o = 2.000$ ***inch. The measured cross section area of the tested specimen at a load of*** $P = 17000\ lbf$ ***is*** $A = 0.1563\ in^2$.

13.( ) The engineering stress of the specimen at this load is (A) $\sigma = 45.8\ kpsi$ (B) $\sigma = 65.5\ kpsi$ (C) $\sigma = 85.5\ kpsi$ (D) $\sigma = 108.8\ kpsi$ (E) None

14.( ) The true stress of the specimen at this load is (A) $\sigma = 45.8\ kpsi$ (B) $\sigma = 65.5\ kpsi$ (C) $\sigma = 85.5\ kpsi$ (D) $\sigma = 108.8\ kpsi$ (E) None

15.( ) The engineering strain of the specimen at this load is (A) $\varepsilon = 0.0027$ (B) $\varepsilon = 0.059$ (C) $\varepsilon = 0.24$ (D) $\varepsilon = 0.27$ (E) None

16.( ) The true strain of the specimen at this load is (A) $\varepsilon = 0.0027$ (B) $\varepsilon = 0.059$ (C) $\varepsilon = 0.24$ (D) $\varepsilon = 0.27$ (E) None

（五）. ***Assume the stress tensor at a point is***

$$[\sigma_{ij}] = \begin{bmatrix} -2 & 4 & 0 \\ 4 & -8 & 0 \\ 0 & 0 & 0 \end{bmatrix} \ (MPa)$$

17.( ) The principal stresses at this point are:

(A) $\sigma_1 = 0; \sigma_2 = 0 \text{ and } \sigma_3 = -10\ MPa$

(B) $\sigma_1 = 12.36; \sigma_2 = 0 \text{ and } \sigma_3 = -32.36\ MPa$

(C) $\sigma_1 = 0; \sigma_2 = -23.0 \text{ and } \sigma_3 = -32.36\ MPa$

(D) $\sigma_1 = 0; \sigma_2 = 0 \text{ and } \sigma_3 = -32.36\ MPa$

(E) None

18.( ) The maximum shear stress at this point is (A) $\tau_{max} = 5.0\ MPa$

(B) $\tau_{max} = 22.36\ MPa$ (C) $\tau_{max} = 16.18\ MPa$ (D) $\tau_{max} = 32.36\ MPa$ (E) None

19.( ) The stress state at this point is (A) a pure bending stress state
(B) a pure torsion stress state (C) a pure transverse shear stress state
(D) a plane stress state (E) None

20.( ) The von-Mises stress at this point is (A) $\sigma' = 5\ MPa$

(B) $\sigma' = 10\ MPa$ (C) $\sigma' = 16.18\ MPa$ (D) $\sigma' = 32.36\ MPa$ (E) None

[i] Choose the correct answers (Multiple Choices) (35%)

(1) Consider the kinematics of particles, which statements are correct?

(A) The displacement of a particle and the distance it travels on its path are the same thing.

(B) Mean acceleration of a particle is the time derivative of its velocity.

(C) The velocity vector of a particle is perpendicular to the path of the particle.

(D) The finite angular displacement is not a vector quantity.

(E) None of the previous statements is correct.

(2) Consider the kinetics of particles, which statements are correct?

(A) A particle that moves with zero acceleration is in equilibrium.

(B) Any reference frame that translates with constant velocity relative to a Newtonian reference frame is itself a Newtonian reference frame.

(C) In Newton's second law, $\mathbf{F} = m\mathbf{a}$, If $\mathbf{a}$ represents a relative acceleration measured with respect to a rotating coordinate system, the equation, $\mathbf{F} = m\mathbf{a}$, still holds.

(D) Consider a planetary motion, as its eccentricity becomes larger, an elliptical orbit becomes more circular.

(E) None of the previous statements is correct.

(3) Which statements are correct?

(A) Consider a body attached to a fixed point by a spring. When the spring is returning to its undeformed position, the work of the force exerted by the spring is negative.

(B) Both the spring force and frictional force are conservative forces.

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

(D) The total work performed by a conservative force is zero when the system moves around a closed path and return to its initial position .

(E) None of the previous statements is correct.

(4) Which statements are correct?

(A) Both momentum and impulse are vector quantities.

(B) A larger force always produces a larger impulse on a body than does a smaller force.

(C) If the moment of momentum of a particle with respect to an arbitrary point Q is conserved, the net force on the particle must be zero.

(D) The acceleration of the center of mass of an isolated system of particles is zero.

(E) None of the previous statements is correct.

(5) Which statements are <u>incorrect</u>?

(A)For a rectilinear translation of a rigid body, one only needs to know the motion of one particle of the body to determine the motion of the body.

(B)The angular velocity of a rigid body that undergoes plan motion depends on the reference line from which its angle of rotation is measured.

(C) The instantaneous center of velocity need not lie in the plane of motion of a rigid-body slice.

(D) The instantaneous center of velocity of a rigid body subjected to plane motion need not be a point in the body.

(E) All of the previous statements are correct.

(6) Consider the rolling motion of a balanced disk with angular speed ω & angular acceleration α. Let r be the radius of the disk, which statements are correct?

(A) When the disk rolls without sliding, the acceleration of the mass center of the disk is equal to rα.

(B) When sliding of the disk is impending, the acceleration of the mass center of the disk is equal to rα.

(C) When the disk rotates & slides at the same time, the acceleration of the mass center of the disk is equal to rα.

(D) For all three cases, speed of the mass center of the disk is equal to rω .

(E) None of the previous statements is correct.

(7) Consider the vibrations of a SDOF (single-degree-of-freedom) system, which statements are correct?

(A) The free vibrations of a damped SDOF system die out as time increases.

(B) The steady-state solution for forced vibration of a SDOF system is independent of the transient solution.

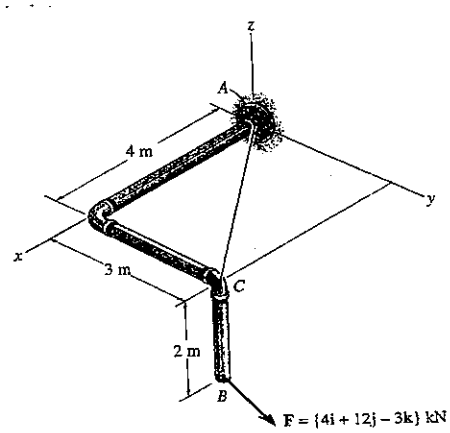
(C) The angular frequency of a freely vibrating undamped SDOF system is called the natural angular frequency of the system..

(D) The total mechanical energy of a freely vibrating undamped SDOF system is constant.

(E) None of the previous statements is correct.

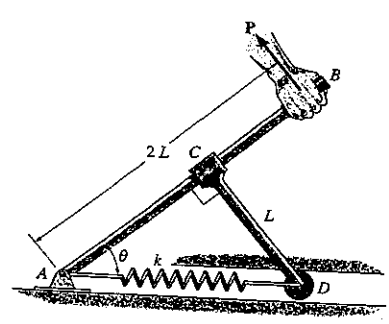
[ii] Determine the moment of the force **F** about an axis extending between A and C. Express the result as a Cartesian vector. (15%)

Figure [ii]



[iii] The two-bar mechanism consists of a lever arm AB and smooth link CD, which has a fixed collar at its end C and a roller at the other end D. Determine the force **P** needed to hold the lever in the position θ. The spring has a stiffness k and unstretched length 2L. The roller contacts either the top or bottom portion of the horizontal guide. (15%)

Figure [iii]



[iv] Consider a system composed of particles P_i, where $1 \le i \le n$. Let m_i be the mass of P_i and $\mathbf{a}_i$ be the acceleration with respect to the newtonian frame of reference OXYZ. Assume there is internal force $\mathbf{f}_{ij}$ exerted on P_i by another particle P_j, with $1 \le i, j \le n$. In addition, all the external forces acting on P_i is denoted as $\mathbf{F}_i$. Denote $\mathbf{r}_i$ the position vector from reference point O to P_i. Please show that (20%)

(a) $\sum_{i=1}^{n} \mathbf{F}_i = \sum_{i=1}^{n} m_i \mathbf{a}_i$,

(b) $\sum_{i=1}^{n} (\mathbf{r}_i \times \mathbf{F}_i) = \sum_{i=1}^{n} (\mathbf{r}_i \times m_i \mathbf{a}_i)$.

[v] Consider a linkage as shown below. Let the mass of rod AB or BC be negligible. The lengths of AB and BC are L_1 and L_2, respectively. The block has a mass m and is subjected to an external force F. If the rod AB is asked to rotate at a constant angular speed ω counterclockwise, what is the torque needed to apply at joint A? (15%)

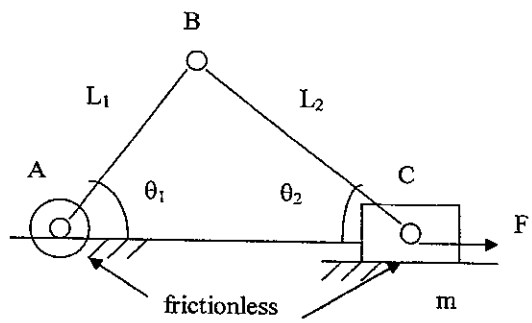


Figure [v]

1. Electronic circuits with feedback can be considered as control systems so that the control theory can be directly applied for the purpose of analysis. Fig. 1 illustrates two standard circuits with operational amplifiers: the inverting amplifier and the non-inverting amplifier.

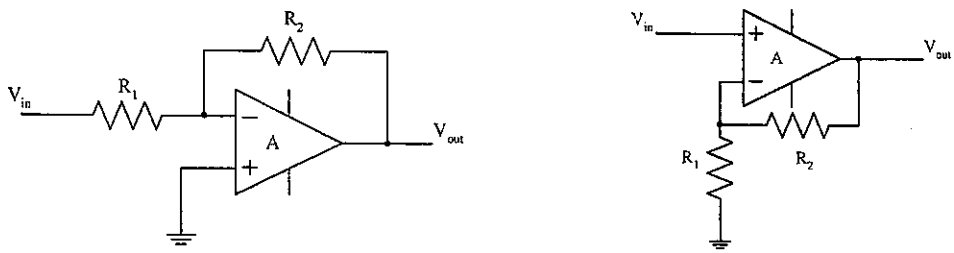


Fig. 1

Assume the operational amplifiers have extremely large input impedance. Therefore, no electric current flows in and out at both input terminals. A is a positive parameter and denotes the gain of the operational amplifier.

(1) Establish the feedback block diagrams for the above two operational amplifier circuits with V_{in} as the input and V_{out} as the output. (20%)

(2) Derive the corresponding transfer functions between V_{in} and V_{out} in terms of R_1, R_2, and A. (20%)

(3) Determine the ranges for A to maintain stability of the circuits. (10%)

2. A simplified diagram of a PM-DC motor is shown in Fig.2. Equivalent moment of inertia and viscous-friction coefficient of the motor are J and b.

(1) Derive and plot the block diagram of the motor. (20%)

(2) Find $\frac{\omega(s)}{U(s)}$ and plot the steady-state characteristics (T/ω) of the motor. (20%)

(3) Explain why in the motor equation T(motor torque) = K*i (constant*current). (10%)

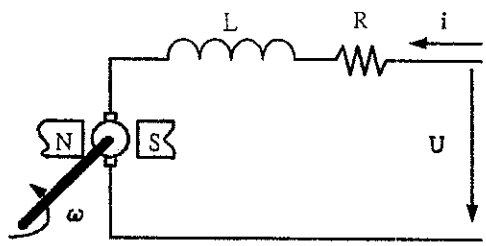


Fig. 2

國立中山大學95學年度碩士班招生考試試題

科目：動力學【機電系碩士班丁組】

第(1)題至第(13)題為選擇題，答錯每題倒扣 1 分

(1) When a system vibrates in a fluid medium, the damping is
(a) Coulomb (b) dry (c) hysteresis (d) solid (e) viscous. (4 %)

(2) The equivalent spring constant of two parallel springs with k_1 and k_2 is
(a) k_1+k_2 (b) $\dfrac{1}{\dfrac{1}{k_1}+\dfrac{1}{k_2}}$ (c) $\dfrac{1}{k_1}+\dfrac{1}{k_2}$ (d) $\dfrac{1}{k_1+k_2}$ (e) k_1k_2. (4 %)

(3) The natural frequency ω_n of a 1-DOF system with mass m and stiffness k is given by
(a) $\dfrac{k}{m}$ (b) $\dfrac{m}{k}$ (c) $\sqrt{km}$ (d) $\sqrt{\dfrac{k}{m}}$ (e) $\sqrt{\dfrac{m}{k}}$. (4 %)

(4) The initial conditions for a lumped, damped system are to be applied to a
(a) stead-state solution (b) total solution (c) transient solution
(d) periodic solution (e) eigen-solution. (4 %)

(5) In torsional vibration, the displacement is measured in terms of a
(a) angular coordinate (b) force coordinate (c) frequency coordinate
(d) linear coordinate (e) moving coordinate. (4 %)

(6) The equivalent mass for a modeled 1-DOF system can be determined using the equivalence of the
(a) internal energies (b) kinetic energies (c) potential energies
(d) internal and potential energies (e) kinetic and potential energies. (4 %)

(7) The particular solution of the linear system $m\ddot{x}+c\dot{x}+kx=F_0\cos\omega t$ is given by $x_p(t)=X\cos(\omega t-\phi)$. The amplitude X of the particular solution can be written as
(a) $F_0[(k-m\omega^2)^2+(c\omega)^2]^{1/2}$ (b) $1/[F_0(k-m\omega^2)^2+(c\omega)^2]^{1/2}$
(c) $[(k-m\omega^2)^2+(c\omega)^2]^{1/2}/F_0$ (d) $F_0/[(k-m\omega^2)^2+(c\omega)^2]^{1/2}$ (e) $F_0/[(k-m\omega^2)^2+(c\omega)^2]$ (4 %)

(8) The phase angle ϕ of the particular solution in Prob. (7) can be given by
(a) $1/\tan^{-1}[m\omega/(k-c\omega^2)]$ (b) $\tan^{-1}[m\omega/(k-c\omega^2)]$ (c) $\tan^{-1}[c\omega/(k-m\omega^2)]$
(d) $1/\tan^{-1}[c\omega/(k-m\omega^2)]$ (e) $\tan^{-1}[k\omega/(m-c\omega^2)]$. (4 %)

(9) In Prob. (7), let $\delta_{st}=F_0/k$ and damping ratio ζ, the maximum value for $(\dfrac{X}{\delta_{st}})_{\max}$ can be given by
(a) $2\zeta\sqrt{1-\zeta^2}$ (b) $2\zeta/\sqrt{1-\zeta^2}$ (c) $\sqrt{1-\zeta^2}/2\zeta$ (d) $1/2\zeta\sqrt{1-\zeta^2}$ (e) $2\zeta\sqrt{1-2\zeta^2}$. (4 %)

(10) The damped natural frequency ω_d for the transient response in Prob. (7) can be given by
(a) $\omega_n\sqrt{1-\zeta^2}$ (b) $\omega_n\sqrt{1-\zeta}$ (c) $\omega_n/\sqrt{1-2\zeta^2}$ (d) $\omega_n\sqrt{1-2\zeta^2}$ (e) $\omega_n/\sqrt{1-\zeta^2}$. (4 %)

(11) The equation of motion of a machine M rotating at frequency ω with an unbalanced mass m, at radius e, modeled as a 1-DOF system can be given by
(a) $m\ddot{x}+c\dot{x}+kx=me\omega^2\sin\omega t$ (b) $M\ddot{x}+c\dot{x}+kx=me\omega^2\sin\omega t$ (c) $(M-m)\ddot{x}+c\dot{x}+kx=Me\omega^2\sin\omega t$
(d) $M\ddot{x}+c\dot{x}+kx=(M-m)e\omega^2\sin\omega t$ (e) $(M-m)\ddot{x}+c\dot{x}+kx=me\omega^2\sin\omega t$. (4 %)

(12) The force transmissibility of a 1-DOF system, subjected to base excitation (with amplitude Y) resulting in transmitted force F_T, is defined as (4 %)

(a) $\frac{F_T}{kY}$ (b) $\frac{kF_T}{Y}$ (c) $\frac{kY}{F_T}$ (d) $\frac{F_T Y}{k}$ (e) $\frac{Y}{kF_T}$. (4%)

(13) The frequency equation of a continuous system is a
(a) ordinary differential equation (b) partial differential equation (c) polynomial equation
(d) transcendental equation. (2 %)

(14) Propose a solution for each of the following problems: (a) How to locate a point having a specified acceleration A in a moving rigid-body (for example, the coupler of a 4-bar linkage), and (b) How to balance the shaking forces and moments due to d'Alembert's accerlations of a mechanism such as a rotating 4-bar linkage? (20 %)

(15) 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 an angular velocity of 80 *rev/min*. (15 %)

(16) Define a simple multiple-degree-of-freedom problem in dynamics and use Lagrange's equation to obtain the solution. (15 %)

國立中山大學95學年度碩士班招生考試試題

科目：靜力學【機電系碩士班丁組】

1. (a)何謂自由體原理(free-body principle)，請詳細說明。(5%)
   (b)三維非共平面力的平衡條件為何?(5%)
   (c)何謂保守力(conservative force)?(5%)
   (d)在保守力場內,請問 force、potential energy 與 kinetic energy 三者之關係為何?(5%)
   (e)何謂自由度(Degree of freedom)?(5%)
   (f)何謂廣義座標(Generalized coordinate)?(5%)

2. 如圖 P2 所示之均質桿,質量為 1-kg，若所有接觸面的靜摩擦係數為 0.2，試求平衡之最大θ值。(10%)

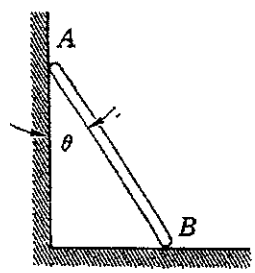


圖 P2

3. 如圖 P3 所示之細長桿,重量為 W，O 點為鉸鍊，於 B 點承受一水平力 P，請利用虛功原理,決定平衡之角度θ。(10%)

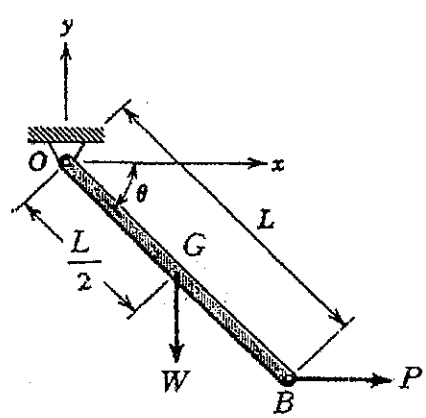


圖 P3

4. As shown in Fig. P4, a man weighing 75-kg sits on a sling and supports himself by a rope wound 1.5 turns around a fixed pulley. Given that the coefficient of friction between the rope and pulley is $\mu = 0.3$, what is the minimum force he can exert to maintain his position? (15%)

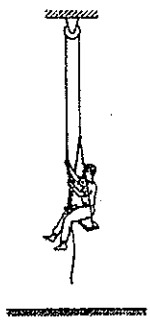


Fig. P4

5. As shown in Fig. P5, the bearings A, B, and C do not exert couples on the bar and do not exert forces in the direction of the axis of the bar. Determine the reactions at the bearings due to two forces on the bar. (15%)

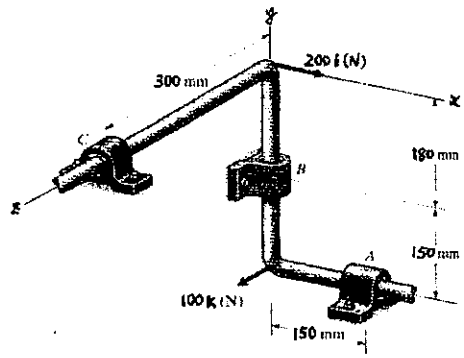


Fig. P5

6. As shown in Fig. P6, the structure supports a conveyor belt used in a lignite mining operation. The cables connected to the belt exert the force **F** at J. As a result of the counterweight W = 8 kip, the reaction at E and the vertical reaction at D are equal. Determine the force **F** and the axial forces in member BG and EF. (20%)

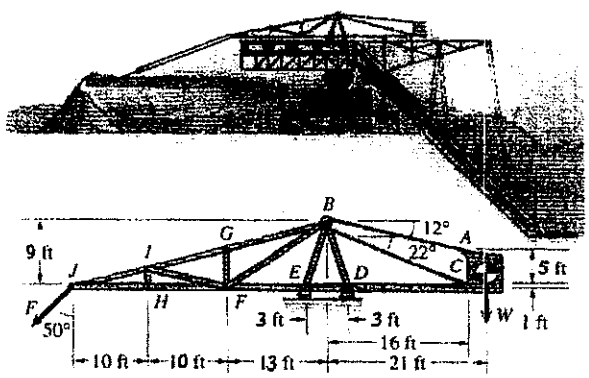


Fig. P6

國立中山大學９５學年度碩士班招生考試試題

科目：材料科學【機電系碩士班戊組選考】

1. Iodine has an orthorhombic unit cell for which the a, b, and c lattice parameters are 0.479, 0.725, and 0.978 nm, respectively. If the atomic packing factor and atomic radius are 0.547 and 0.177 nm, respectively, determine the number of atoms in each unit cell. (15%)

2. Cite the primary differences between elastic, anelastic, and plastic deformation behaviors. (20%)

3. Briefly explain why HCP metals are typically more brittle than FCC and BCC metals. (15%)

4. For a 99.65 wt% Fe-0.35 wt % C alloy at a temperature just below the eutectoid, determine the following:
(a) The fractions of total ferrite and cementite phases. (10%)
(b) The fractions of the proeutectoid ferrite and pearlite. (10%)
(c) The fraction of eutectoid ferrite. (10%)

5. Compute the volume percent of graphite V_{gr} in a 3.5 wt% C cast iron, assuming that all the carbon exists as the graphite phase. Assume densities of 7.9 and 2.3 g/cm^3 for ferrite and graphite, respectively. (10%)

6. Compute the percent cold work (% CW) of a cylindrical copper rod if it is cold worked such that the diameter is reduced from 15.2 mm to 12.2 mm ?(10%)

國立中山大學９５學年度碩士班招生考試試題

科目：普通化學【機電系碩士班戊組選考】

1. 製作矽晶圓的原料為砂子(SiO_2)，其純化的過程如下：第一步為將砂子與碳共燒，第二步為將所成之產物與氯氣反應，並獲得一常溫為液態之產物，液態之物質可利用過濾、蒸餾等方式純化，最後步驟乃再利用氫氣將純化後之物質還原成高純度矽，此乃半導體等級之矽。請寫出上列三步驟之化學反應式。(10%)

2. 請列舉三種化學腐蝕之發生原因，及其防治方法。 (10%)

3. 請寫出乙醇、丙酮、異丙醇、乙二醇、乙醛之英文化學名及化學式，並排列其沸點高低。 (10%)

4. 請說明利用 Infrared spectroscopy 量測樣品的基本原理，以及 IR spectroscopy 適合用來量測何種樣品。(10%)

5. 請說明要調製濃硫酸與雙氧水溶液，使其成為體積比例為 3：1 的 piranha solution 之步驟及其應該注意之事項。(10%)

6. Determine the **time required** to electroplate a 0.1-cm-thick layer of copper onto a 1 cm × 1 cm cathode surface. The applied current is 1 A. (density of Cu = 8.96 g/cm^3, Molecular weight of Cu = 63.54 g/mole, 1 Faraday = 96500 coul.) (10%)

7. Calculate the standard emf of the following voltaic cell at 25°C using standard electrode potentials. $Al_{(s)}|Al^{3+}{}_{(aq)}||Fe^{2+}{}_{(aq)}|Fe_{(s)}$, where $E°_{Al}$ = -1.66 V, $E°_{Fe}$ = -0.41 V at 25°C. (10%)

8. The following process $2CH_3COOH_{(l)} + O_{2(g)} \rightarrow 2HC_2H_3O_{2(l)}$ is reacted under pressure at 60°C. In lab., 20.0 g CH_3COOH and 10.0 g O_2 were put into a reaction vessel.
   a. How many grams of acetic acid can be produced by this reaction from these amounts of reactants? (5%)
   b. How many grams of the excess reactant remain after the reaction is complete? (5%)

9. The reaction $CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2(g)} + H_{2(g)}$ is used to increase the ratio of hydrogen in synthesis gas (mixtures of CO and H_2). Suppose you start with 1.00 mol of carbon monoxide and 1.00 mol of water in a 50.0 L vessel. How many moles of **each substance** are in the equilibrium mixture at 1000°C? The equilibrium constant K_c at this temperature is 0.58. (10%)

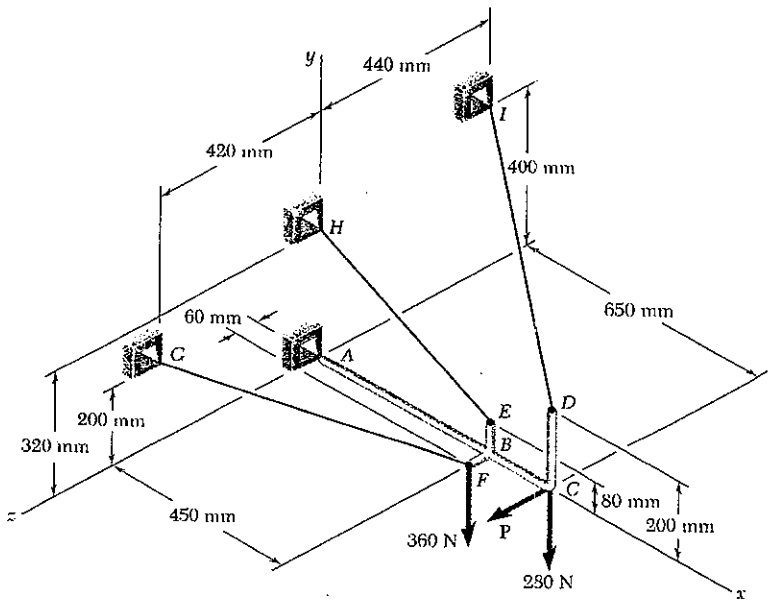
10. Describe how to prepare **1N of** $NaOH_{(aq)}$ from solid sodium hydroxide and how to prepare **1M of** $HCl_{(aq)}$ from 12M of $HCL_{(aq)}$. (10%)

國立中山大學９５學年度碩士班招生考試試題

科目：應用力學【機電系碩士班戊組選考】

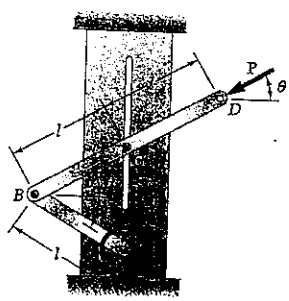
每題 20 分

1. The frame shown below is supported by three cables and a ball-and-soclet joint at A. Determine the tension in each cable and the reaction at A.
   For (1) P=0 (2) P is not 0.



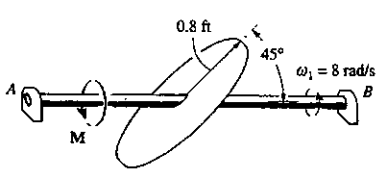
2.

The pin at C is attached to member BCD and can slide along a slot cut in the fixed plate shown. Neglecting the effect of friction, derive an expression for the magnitude of the couple **M** required to maintain equilibrium when the force **P** which acts at D is directed (a) as shown, (b) vertically downward, (c) horizontally to the right.



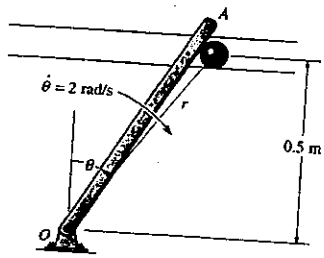
3.

The circular disk has a weight of 15 lb and is mounted on the shaft AB at an angle of 45° with the horizontal. Determine the angular velocity of the shaft when $t = 3$ s if a constant torque $M = 2$ lb · ft is applied to the shaft. The shaft is originally spinning at $\omega_1 = 8$ rad/s when the torque is applied.



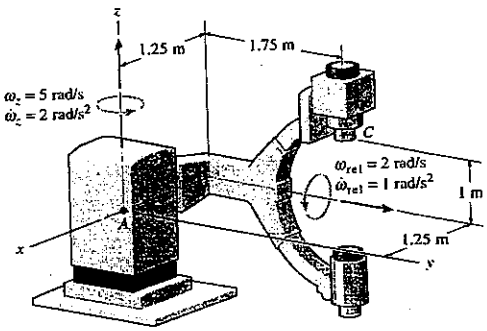
4.

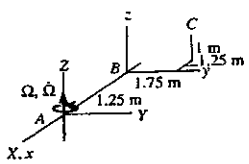
The particle has a mass of 0.5 kg and is confined to move along the smooth horizontal slot due to the rotation of the arm OA. Determine the force of the rod on the particle and the normal force of the slot on the particle when $\theta = 30°$. The rod is rotating with a constant angular velocity $\dot{\theta} = 2$ rad/s. Assume the particle contacts only one side of the slot at any instant.



5.

During the instant shown the frame of the X-ray camera is rotating about the vertical axis at $\omega_z = 5$ rad/s and $\dot{\omega}_z = 2$ rad/s^2. Relative to the frame the arm is rotating at $\omega_{rel} = 2$ rad/s and $\dot{\omega}_{rel} = 1$ rad/s^2. Determine the velocity and acceleration of the center of the camera C at this instant.





國立中山大學95學年度碩士班招生考試試題

科目：機械製造學【機電系碩士班戊組選考】

一、是非題 (每題2分，共30分)

( ) 1.金屬在再結晶溫度以上的各種塑作加工方法稱爲熱作。
( ) 2.冷作時氧化機會很少，可輒出熱作更薄之片或箔。
( ) 3.滑動發生時，若原子方向維持不變就形成雙晶現象。
( ) 4.金屬變形的原因中，其最主要的是滑動。
( ) 5.純金屬皆比其合金能承受較多的冷加工。
( ) 6.熱處理一辭顧名思義乃是利用“熱量”來處理工件之意。
( ) 7.鑄鋼就是用鑄造方法成形的鋼材。
( ) 8.鋼鐵材料的降伏點及彈性係數因溫度的升高而降低。
( ) 9.利用人工合成之有機高分子化合物稱爲合成樹脂。
( ) 10.塑膠的重量輕、防潮、抗腐及電氣絕緣性良好，常用以代替木材。
( ) 11.熱塑性塑膠成形後，便不能再受熱軟化再成形。
( ) 12.一般俗稱的PVC塑膠是指聚氯乙烯塑膠。
( ) 13.放電加工特別適合於硬度高脆性大的材料加工。
( ) 14.化學加工法不適於硬脆之材料加工，可免生變形或破裂。
( ) 15.金屬表面處理的目的是增進美觀提高品質進而促成有利銷路。

二、選擇題 (每題2分，共20分)

( ) 1.下列那種鍛造方法是利用緩慢的擠壓作用，使塑性金屬變形 ①落錘式鍛造 ②端鍛造 ③壓力鍛造 ④輥軋鍛造。
( ) 2.拉伸抽拉成形的主要缺點 ①夾持部份廢料太多 ②設備費用高 ③材料易發生破裂 ④操作程序複雜。
( ) 3.退火處理中何者加熱的溫度最高 ①完全退火 ②均質化 ③球化退火 ④弛力退火。
( ) 4.退火處理中何者加熱溫度最低且所需時間最短 ①均質化 ②球化退火 ③弛力退火 ④再結晶退火。
( ) 5.常作爲食品包裝的材料是 ①尼龍 ②壓克力 ③聚乙烯 ④聚丙烯。
( ) 6.塑膠原料中能增進流動性的是 ①填充劑 ②溶劑 ③安定劑 ④著色劑。
( ) 7.射出機成形一循環的時間約爲 ①2～10分②2～10秒③10秒～40秒 ④10秒～2分。
( ) 8.低溫模塑成形的製品其成本 ①高昂 ②增加 ③低廉 ④不一定。
( ) 9.放電加工的工作液是屬 ①導電體 ②絕緣體 ③浸蝕性 ④熔化性。
( ) 10.電化加工時的工作物是安裝在 ①陰極 ②陽極 ③均可 ④電解槽底。

國立中山大學95學年度碩士班招生考試試題

科目：機械製造學【機電系碩士班戊組選考】

三.填充題 (每格 2 分，共 30 分)

1.當結晶經冷作而變形破壞時，會使材料的強度和硬度增加，此現象稱爲 __。
2.壓印法又稱 __。
3.珠擊法係用 __ 或 __ 將鋼珠噴出。
4.一般工業上使用的探碳鋼可歸類成 __、 __、 __ 等三種。
5.由鐵碳平衡圖可簡潔地了解鋼的 __、 __、 __ 三者的關係。
6.鐵碳合金的含碳量在 __ 之間謂“鋼”；含碳量在 __ 之間謂“鑄鐵”。
7.最常見的化學性表面硬化法有 __、 __ 兩種。
8.沃斯田鐵與雪明碳鐵的細密共晶物稱爲 __。

四. 問答題 (共 20 分)

1. 退火、淬火及回火的目的各爲何?(10 分)
2. 何謂熱作及冷作，有何優點與缺點?(10 分)

國立中山大學９５學年度碩士班招生考試試題

科目：材料力學【機電系碩士班戊組選考】

1. The beam is subjected to the load at its end, as shown in Fig. (1). Determine the maximum principal stress at point B. (25%)

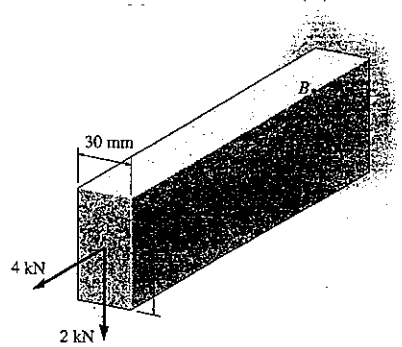


Fig. (1).

2. Determine the shear stress in the beam at point A, which is located at the top of the web, as shown in Fig. (2). (25%)

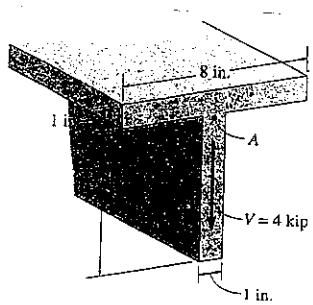


Fig. (2).

3. The three-bar truss is subjected to a horizontal force of 5 kip, as shown in Fig. (3). If the cross-sectional area of each member is 0.2 in^2, determine the horizontal displacement at point B. E = 29x10^3 ksi. (25%)

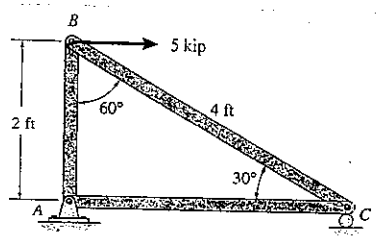


Fig. (3).

4. The state of stress at a point is shown on the element, as shown in Fig. (4). Determine (a) the principal stresses and (15%) (b) the maximum in-plane shear stress(10%). Specify the orientation of the element in each case.

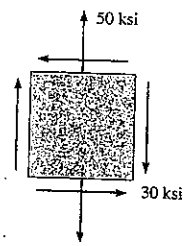
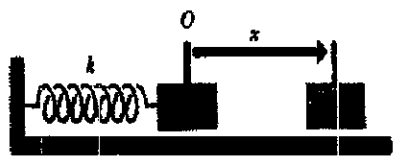


Fig. (4).

國立中山大學９５學年度碩士班招生考試試題

科目：普通物理【機電系碩士班戊組選考】

一、將彈簧固定一物體如右圖所示。在彈簧由平衡時自由端的位置施力拉一距離 x 時位移與力成正比，而 4 N 之力可有 0.02 m 之位移。今縛一質量 2-kg 之物體施力將其拉 0.04 m 之位移然後將其釋放。求(1)彈簧 force constant k，(2)物體之運動微分方程式，(3)振動之週期，(4)振動之頻率(5)物體振動時之最大速度(6)物體振動時之最大加速度。(30%)



二、一 10cm 長之鐵棒與一 20 cm 長之銅棒，每根棒子有正方形邊長 2 cm 之截面。(1) 今將二棒子在末端焊接一起，鐵棒之另一末端與水蒸汽 100℃ 接觸，而銅棒之另一自由末端與冰 0℃ 接觸。求在兩根棒子焊接處之溫度及熱流速率。(鐵熱傳係數 $k = 50.2\ Js^{-1}m^{-1}℃^{-1}$，銅熱傳係數 $k=385\ Js^{-1}m^{-1}℃^{-1}$)。(2)又若二棒子是分離的，同時每根棒子之一末端與水蒸汽 100℃ 接觸，而另一末端與冰 0℃ 接觸。求在兩根棒子熱流速率。(20%)

三、一柴油引擎的壓縮比為 15，即空氣在汽缸中將被壓縮至原初始體積之 1/15。今在引擎的汽缸中有空氣壓力為 $1.0\cdot10^5$ Pa 及其初始溫度為 27℃ (= 300 K)，求壓縮後最後之壓力及溫度。(空氣是氧與氮的混合氣 $\gamma = 1.40$) (20%)

四、利用高斯定律求下列之電場：(1)一點電荷 q 距離 r 處之電場。(2) 一電荷均勻分佈具有電荷密度 ρ，半徑為 R 之球體，求距離球中心 r 處之電場 ($r < R$)。 (3) 一無限長，具有線電荷密度 λ 的之細金屬導線，求距離導線 r 處之電場。(4) 一無限大之金屬薄板，具有面電荷密度 σ，求距離表面 d (>>其厚度) 位置處之電場。(5) 又一半無限大之金屬厚板，具有面電荷密度 σ，求在距離金屬表面內部及外部位置 d 處 (<< 其半無限大之厚度) 之電場。(6) 二平行板金屬面積 A，距離 d，具有正、負電荷密度 σ 的電容器，其正中間位置之電場。(30%)