● 本C科目試題含工程數學、材料科學、材料力學三科目之試題。其中材料科學(第1～30題)及材料力學(第31～60題)為選擇題，每一題為4選1，每一題答對得1分，答錯倒扣0.25分，未作答者不給分亦不扣分；工程數學為計算問答題(計6題)，各題所占分數為5分；本科目滿分為90分。

第一部分 : 選擇題(60分)

1. An electrochemical cell consisting of iron and copper electrodes, each of which is immersed in am 1M solution of its ion. In this cell, (a) iron corrodes as cathode (b) iron corrodes as anode (c) copper corrodes as cathode (d) copper corrodes as anode
2. For the following pairs of alloys that are coupled in seawater, which pair of stainless steel (s.s) will corrode (a) s.s vs iron (b) s.s vs aluminum (c) s.s vs magmisum (d) s.s vs brass
3. In cathodic protection, the sacrificial anode usually used is (a) Mg (b) Cu (c) stainless steel (d) Inconel
4. The band gap of a semiconductor such as Si is about (a) 8.0 ev (b) 6.0 ev (c) 4.0 ev (d) 1.0 ev
5. The diode of p-n junction is an electronic device that allows the current to flow in (a) four (b) three (c) two (d) one direction(s).

6. (a)$MgAl_2O_4$ (b) $BaTiO_3$ (c) Al_2O_3 (d) NaCl is piezoelectric material which is utilized in translucers.
7. The material having the highest thermal conductivity is (a)Al (b) Cu (c) Au (d) diamond.
8. Diamagnetism is (a) very strong (b) strong (c) weak (d) very weak form of magnetism.
9. The net spin moment of Fe^{3+} ion has (a) 2 (b) 3 (c) 4 (d) 5 Bohr magnetons.
10. $SmCo_5$ is a (a) soft (b) medium (c) hard (d) rare magnet.

11. Please select the right equation of Gibbs phase rule.
    Assume P is the number of phase present.
    F is the number of degree of freedom
    C is the number of components
    N is the number of noncompositional variables (e.g. temperature and pressure)
    (a) P-F = C-N (b) P-C = F-N (c) P+C = F+N (d) P+F = C+N
12. For solid state transformations, the fraction of transformation y is a function of

time t as follows :

$$y = 1 - \exp(-kt^{n})$$

where k and n are time-dependent constants for the particular reaction. The above expression is often referred as the (a) Fick's Law (b) Martensitic transformation (c) Avrami equation (d) Kinetics equation

13. Steels which carbon is the prime alloying element are termed (a) plane carbon steels (b) alloy steels (c) Martensite steels (d) Bainite steels.
14. " Severity of Quench" is a term often used to indicate the rate of cooling; the more rapid the quench, the more severe the quench. Of the three most common media-water, oil and air, which one produces the most severe quench (a) water (b) oil (c) air (d) same.
15. A fabrication process whereby a totally molten metal is poured into a mold cavity having the desired shape is called (a) casting (b) rolling (c) sintering (d) annealing.

16. Please select one property that might exist with a steel weld that was cooled rapidly. (a) very corrosive (b) very brittle (c) very ductile (d) very soft.
17. One type of defect involves a cation-vacancy and a cation-interstitial is called a (a) Frenkel defect (b) Schottky defect (c) stacking fault (d) twin plane.
18. Which one of the following has a very strong covalent bonding (a)MgO (b) SiO_2 (c)NaCl (d) Diamond.
19. A state for ionic compounds wherein there is the exact ratio of cations to anions as predicted by the chemical formula is called (a) neutrality (b) tetragonal (c) octahedral (d) stoichiometry.
20. If the ethylene gas is subjected catalytically to appropriate conditions of temperature and pressure, it will transform to (a) polypropylene (b) polyvinyl chloride (c) polyethylene (d) Alde hydes.

21. Appreciable quantities of a solute may be accommodated in the substitutional type of solid solution only when the difference in atomic radii between the two atom types is less than about:

    (a) $\pm 10\ \%$ (b) $\pm 15\ \%$ (c) $\pm 20\ \%$ (d) $\pm 25\ \%$
22. The volume of an FCC unit cell in terms of the atomic radius R is:

    (a) $14R^3\sqrt{2}$ (b) $14R^3\sqrt{3}$ (c) $16R^3\sqrt{2}$ (d) $16R^3\sqrt{3}$
23. The unit cell geometry of Orthorhombic crystal system is:

    (a) $a \neq b \neq c,\ \alpha = \beta = \gamma = 90^\circ$ (b) $a = b = c,\ \alpha = \beta = \gamma \neq 90^\circ$

    (c) $a \neq b \neq c,\ \alpha \neq \beta \neq \gamma \neq 90^\circ$ (d) $a \neq b \neq c,\ \alpha = \gamma = 90^\circ \neq \beta$
24. The relationship between the grain size number (n) and the average number of grains per square inch at a magnification of 100x (N) is:

(a) $N = 2^{n-1}$ (b) $N = 2^{2n-1}$ (c) $N = 2^{3n-2}$ (d) $N = 2^{4n-3}$

25. The modulus of resilience, Ur, =
 (a) $(\sigma_y^2)/(2E)$ (b) $(\sigma_y)/(2E^2)$ (c) $(2\sigma_y^2)/(E)$ (d) $(\sigma_y^2)/(2E^2)$

26. The relationship between true stress (σ_T), true strain (ε_T), engineering stress (σ) and engineering strain (ε) is:
 (a) $\varepsilon = 1/\ln(1+\varepsilon_T)$ (b) $\varepsilon_T = 1/\ln(1+\varepsilon)$
 (c) $\varepsilon = \ln(1+\varepsilon_T)$ (d) $\varepsilon_T = \ln(1+\varepsilon)$

27. The slip systems for FCC is:
 (a) {111} <100> (b) {100} <111> (c) {110} <111> (d) {111} <110>

28. If it is assumed that an internal crack is similar to an elliptical hole through a plate, and is oriented perpendicular to the applied stress, the maximum stress occurs at the crack tip and may be approximated by (σ_o: normal applied tensile stress; ρ: radius of curvature of the crack tip; a: half the length of the internal crack):
 (a) $\sigma_o\sqrt{(a/\rho)}$ (b) $\sigma_o\sqrt{(2a/\rho)}$
 (c) $\sigma_o\sqrt{(a/2\rho)}$ (d) $2\sigma_o\sqrt{(a/\rho)}$

29. If it is assumed that an internal crack is similar to an elliptical hole through a plate, and is oriented perpendicular to the applied stress, the critical stress required for crack propagation in a brittle material is (E: modulus of elasticity; γ: specific surface energy; a: one half the length of the internal crack):
 (a) $\sqrt{(2E\gamma/\pi a)}$ (b) $\sqrt{(E\gamma/\pi a)}$
 (c) $\sqrt{(E\gamma/2\pi a)}$ (d) $2\sqrt{(E\gamma/\pi a)}$

30. Steady-state creep rate can be expressed as a function of stress and temperature as shown below (K and n are material constants; Q_c is activation energy for creep):

 (a) $K\sigma^n \exp(-Q_c/(RT))$ (b) $K\sigma^n \exp(-Q_c/(2RT))$

 (c) $K\sigma^{1/n} \exp(-Q_c/(RT))$ (d) $K\sigma^{1/n} \exp(-Q_c/(2RT))$

31. The rod *ABCD* is made of an aluminum alloy for which *E*=70GPa. For the loading shown, and neglecting the weight of the rod, determine the deflection of point *B* ?
(a)0.791 (b)0.983 (c)5.71 (d)12.53 ㎜. (shown in Fig. 1.)

(背面仍有題目,請繼續作答)

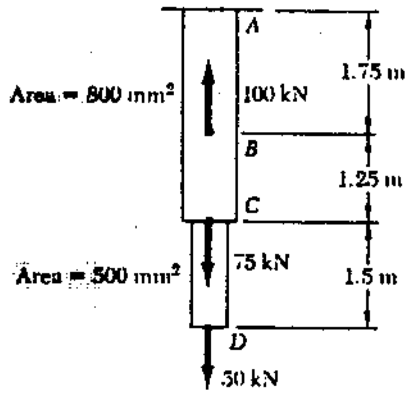


Fig. 1.

32. The length of the 2-mm-diameter steel wire *CD* has been adjusted so that with no load applied, a gap of 1.5mm exists between the end B of the rigid beam *ACB* and a contact point *E*. Knowing that E=200GPa, determine where a 20-kg block should be placed on the beam in order to cause contact between *B* and *E*？（shown in Fig. 2.） (a)0.307 (b)0.093 (c)31.25 (d)92.6 ㎜.

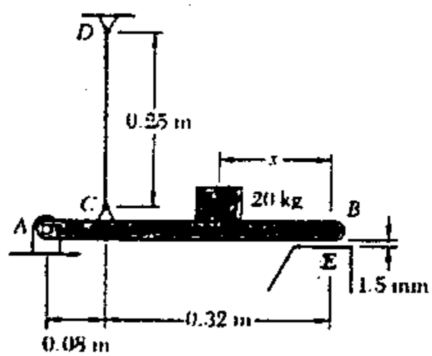


Fig. 2

33. A slightly tapered bar *AB* circular cross section and length 3.0m is supported at *B* and subjected to a tensile load 78.54kN at the free end *A*, the diameters of the bar at ends *A* and *B* are 20mm and 30mm, respectively. If the elongation of the bar due to the load is 5mm, find modulus of elasticity *E* of the bar. (a)210Gpa (b)140Gpa (c)100Gpa (d)70Gpa

34. A rigid bar *BD* is supported by a pin support at *B* and by two wires attached at *C* and *D* (see figure). The wires are identical except for length and are just taut (but free from stress) before the load *P* is applied. Find the tensile forces T_c and T_d produced in the wires by a load *P*=5000N. （shown in Fig. 3.）

(a)T_c=5.36kN,T_d=5.15kN (b) T_c=3.24kN,T_d=7.58kN (c) T_c=493N,T_d=761N (d) T_c=127N,T_d=761N

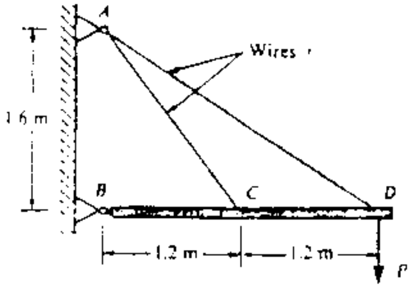


Fig. 3

35. The composite bar shown in Fig. P-15 is firmly attached to unyielding supports. An axial load P=200kN is applied at 20℃. Find the stress in aluminum at 60℃. Assume α=11.7μm/(m-℃) for steel and 23.0μm/(m-℃) for aluminum. （shown in Fig. 4.）

(a) σ_a=181MPa (b) σ_a=81.2MPa (c) σ_a=18.7MPa (d) σ_a=0MPa

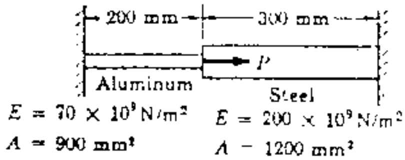


Fig. 4

36. Each cable has a cross-sectional area of 100mm^2 and is made of an elastoplastic material for which δ_Y=320Mpa and E=200Gpa. A force Q is applied at C to the rigid bar ABC and is increased gradually from 0 to 45 kN and then reduced to zero. Knowing that the cables were initially taut, determine the final deflection of point C. (*Hint :* In part c, cable CE is not taut.) （shown in Fig. 5）

(a)10.33 ㎜ (b)8.25 ㎜ (c)5.20 ㎜ (d)0 ㎜

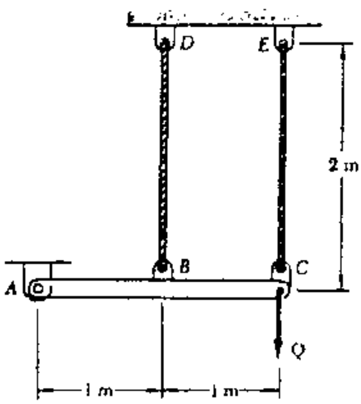


Fig. 5

37. The steel rod ACB is attached to rigid supports and is unstressed at a temperature

of 20℃. The steel is assumed elastoplastic with δ_Y=250Mpa and E=200Gpa.The temperature of both portions of the rod is then raised to 120℃. Knowing that α=11.7×10^{-6}/℃), determine the deflection of point C. （shown in Fig. 6.）
(a) 46.2 μm ← (b) 46.2 μm → (c) 93.0 μm ← (d)93.0 μm →.

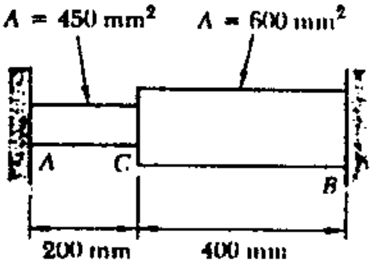


Fig. 6

38. Construct the moment diagram for the two beams loaded as shown and connected by the hinge joint at B. Specify the bending moment at A. （shown in Fig. 7.）
(a)M_A=－16kN-m (b) (A)M_A=－32kN-m (c)M_A=－48kN-m (d)M_A=－64kN-m.

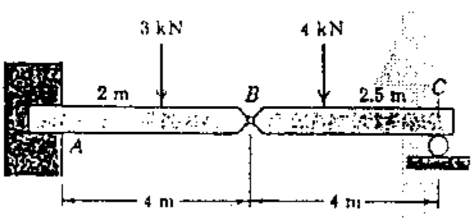


Fig.7

39. A symmetric five-bar truss is loaded by a vertical force P applied at joint F (see figure). All bars have the same length L, same cross-sectional area A, and same modulus of elasticity E. Determine the deflection δ of joint D（shown in Fig. 8.）

(a) $\delta_D = \dfrac{5PL}{3AE}$ (b) $\delta_D = \dfrac{PL}{AE}$ (c) $\delta_D = \dfrac{PL}{3AE}$ (d) $\delta_D = \dfrac{PL}{\sqrt{3}AE}$

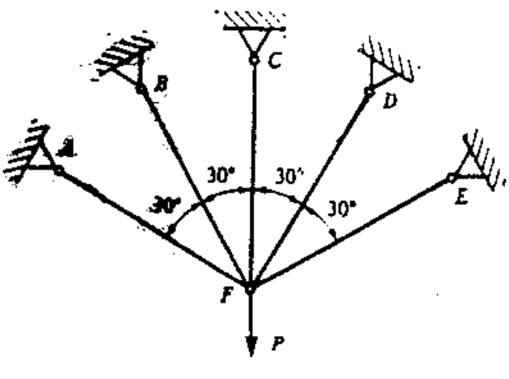


Fig. 8

40. For the loading shown in Fig. 9，if $\sigma_y = -\sigma_x$，determine the volume strain

(a) $2\frac{1+2V}{E}\sigma_x$ (b) $2\frac{1-2V}{E}\sigma_x$ (c) $-2\frac{1+2V}{E}\sigma_x$ (d) 0。

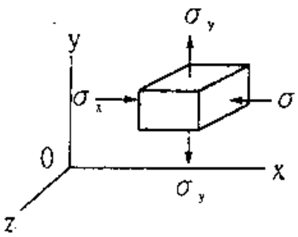


Fig. 9

41. An element of a material is subjected to a biaxial stress state of σ_x and σ_y in x and y direction, respectively. It is false that:

(a) $\varepsilon_x \neq 0$, (b) $\varepsilon_y \neq 0$, (c) $\varepsilon_z = 0$, (d) $\tau_{xy} \neq 0$

where σ_z is the normal stress in z direction, ε_x, ε_y and ε_z are the normal strains in x, y and z directions, respectively. τ_{xy} is the shear strain in x-y plane.

42. A 100,000 lb_f axial load is applied to a 1 x 4 x 90-in. rectangular bar. When loaded, the length has increased 0.09 in. Determine the modulus of elasticity.

(a) 10,000 ksi, (b) 15,000 ksi, (c) 17,500 ksi, (d) 25,000 ksi

43. For isotropic material, which of the following expression for shear stress is correct?

(a) $\tau_{xy} = \frac{E}{2(1+\nu)}$, (b) $\tau_{xy} = \frac{E}{2(1-\nu)}$, (c) $\tau_{xy} = \frac{2E}{1-\nu}$, (d) $\tau_{xy} = 2E(1+\nu)$

where E and ν are Young's modulus and Poisson's ratio, respectively.

44. At the proportional limit, a 200-mm gage length of a 15-mm diameter alloy bar has elongated 0.90 mm and the diameter has been reduced 0.022 mm. The axial load carried was 62.6 kN. Determine the Poisson's ratio.

(a) 0.326, (b) 0.30, (c) 0.284, (d) 0.35

45. The area under theentire stress-strain curve from zero to rupture give the proprety known as the (a) tensile strength (b) modulus of resilience (c) modulus of toughness (d) rupture strength

46. The maximum strain energy per unit volume that a material will absorb without inelastic deformation and is the area under the straight-line portion of the stress-strain diagram is defined as the (a) yield strength (b) modulus of resilience (c) modulus of toughness (d) proof stress

47. In region of support and load application, the stress distribution varies from the normal value. Although localized distortions in such regions produced stress distributions different from the theoretical distributions, these localized effects disappear at some distance from such location. Abovementioned statement is

known as (a) Mohr's (b) Hooke's (c) Saint-Venant's (d) Young's

48. Stress concentration in the case of static loading is not significant because the material will yield inelastically in the region of high stress and, with the accompany redistribution of stress, the material should have excellent (a) ultimate tensile strength (b) ductility (c) impact absorb energy (d) toughness

49. A solid circular steel is supported at the top end and fitted with a loading flange at th bottom, then a weight collar can slide freely on the rod. When the weight collar dropped from very limit height(h=0), compare to the static load under an identical condition, the value of weight will be (a) same (b) 1.5 times (c) 2 times (d) 3times

50. Although no body is perfectly rigid. Most engineering structures and machines are designed stiff, the solution of the equilibrium equations treats the structure as though it were regid. A regid body is in equilibrium when the resultant of the vector sum and the vector sum of the moment of the external force acting on the body is (a) 0 (b) 1 (c) 2 (d) 3

51. A material loaded in one direction will undergo strains perpendicular to the direction of the load in addition to these parallel the load. The ratio of the lateral or perpendicular strain to the longitudinal or axial strain is called (a) strain energy (b) elongation (c) Poission's ratio (d) Modulus of elasticity

52. An allowable stress is defined as the maximum stress permitted in the design computation. The factor of safety(FS) may be defined as the ratio of the strength of the material to the maximum computed stress. It is customary to design for the load required to produce failure, which is large then the estimated actual load, because most design problem involve (a) unknown variables (b) cost (c) afterservice (d) market

53. The strength of a structural member acted on by an axial load was directly proportional to the magnitude of the load applied to the member. The initial portion of the stress-strain diagram for most materials used in the engineering structures is a straight line and is present by (a) Secant formular (b) Hooke's law (c) Saint-Venant's principle (d) Euler's formular

54. Columns are long, straight, prismatic bar subjected to compressive loads. As long as a column remain straight, it can be analized as an axially load member, however, if a column begins to deform laterally, the deflection may become large and catastrophic failure called (a) buckling (b) bending (c) compression (d) shearing

55. A useful pictorial or graphic interpretation of the transformation equations for plane stress, involves the construction of a circle in such a manner that the coordinates, of each point represent the normal and shearing stresses on the plane through the stress point. This representation, commonly called (a) stress

concentration diagram (b) Mohr's diagram (c) Mohr's circle (d) Mohr's distribution

56. In the simplest qualitative terms, stress is the intensity of force. A body must be able to withstand the intensity of an internal force, if not, the body may rupture or deform excessively. Force intensity is force divided by the (a) volume (b) weight (c) area (d) length
57. Loads applied to a structure or machine are generally transmitted to the individual members through connections which use rivet, bolt, pins, or welds. In all of these connections, one of the most significant stresses induced is a (a) tensile stress (b) bending stress (c) shearing stress (d) compression stress
58. Laboratory experiments indicate that both normal and shearing stresses under axial loading are important because a brittle material loaded in tension will fail in tension on a transverse plane, whereas a ductile material loaded in tensile will fail in shear on a (a) 30 degree (b) 45 degree (c) 60 degree (d) 75 degree plane
59. When the motion of a body is changed, the force necessary to produce this acceleration is called a dynamic force or load. A suddenly applied load is also called an impact load. Under impact loading if there is elastic action, until equilium is established the load system will (a) elongate (b) deform (c) swing (d) vibrate
60. The property indicating the resistance of a material to failure by creep is known as the creep limit and is define as the maximum stress for which the plastic strain will not exceed a specified amount. The creep limit is important when designing parts to be fabricated will be subjected to (a) high loading (b) high temperature (c) high strain (d) high stress

第二部分：計算問答題（30 分）

1. Let

$$f(x)=\begin{cases} e^{-x} & for \quad x\ge 0 \\ e^{x} & for \quad x\le 0 \end{cases}$$

Find the Fourier integral for f(x). (5 points)

2. Solve the wave equation with zero initial displacement:

$$\frac{\partial^2 y}{\partial t^2}=a^2\frac{\partial^2 y}{\partial x^2} \qquad (0<x<L,\ t>0),$$

$$y(0,t)=y(L,t)=0 \qquad (t>0),$$

$$y(x,0)=0 \qquad (0<x<L),$$

$$\frac{\partial y}{\partial t}(x,0)=g(x) \qquad (0<x<L).$$

(5 points)

3. Find the integral $I=\int_{\pi}^{\pi}\sin 2x\cos x\,dx$. (5 points)

4. A and B are square matrices of the same size. Show that, in general, the matrix product $(A+B)^2\neq A^2+2AB+B^2$. (5 points)

5. Consider a nuclear fuel element of spherical form as shown below. It consists of a sphere of fissionable material with radius $R^{(F)}$, surrounded by a spherical shell of aluminum cladding with outer radius $R^{(C)}$. Inside the fuel element fission fragments are produced which have very high kinetic energies. Collisions between the fragments and the atoms of the fissionable material provide the major source of the thermal energy in the reactor. Such a volume source of thermal energy resulting from nuclear fusion we call Sn (cal / cm^3 sec). This source will not be uniform throughout the sphere of fissionable material; it will be the smallest at the cell of the sphere. It is known that the source can be approximated by a simple parabolic function:

$$Sn=Sno\left[1+b\left(\frac{r}{R^{(F)}}\right)^2\right]$$

Here Sno is the volume rate of heat production at the center of the sphere and b is a dimensionless constant between 0 and 1. Assume that the governing differential equations for the heat fluxes in the fissionable fissionable sphere and the aluminum cladding are as follows:

$$\frac{d}{dr}(r^2 q_r^{(F)}) = Sno\, r^2\left[1 + b(\frac{r}{R^{(F)}})^2\right]$$

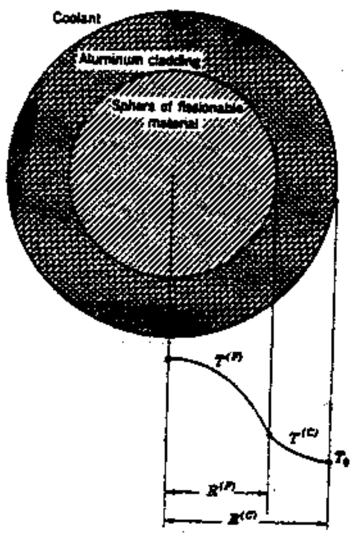
And

$$\frac{d}{dr}(r^2 q_r^{(C)}) = 0$$

The boundary conditions are as follows:

At $r = 0$, $q_r^{(F)}$ is not infinite, at $r = R^{(F)}$, $q_r^{(F)} = q_r^{(C)}$

Please find the heat flux profile in the fissionable sphere. (5 points)



Temperature distribution in a spherical nuclear fuel assembly.

6. The system description is the same as in Question 5. Please find the heat flux profile in the aluminum cladding. (5 points)