編號： 121　系所：材料科學及工程學系　　科目：C科目

本試題是否可以使用計算機：☑可使用 ，□不可使用　（請命題老師勾選）

C 卷：工程數學(10 題[1-10], 每題 3 分)、材料力學(10 題[11-20], 每題 3 分)、材料科學導論(30 題[21-50], 每題 1 分)。滿分 90 分。倒扣至零分為止。

科目名稱： 工程數學

每題為 4 選 1，每一題答對得 3 分，答錯倒扣 0.75 分。

1. The eigenvalues of the symmetric matrix $A=\begin{bmatrix}0 & -1 & 0\\ -1 & -1 & 1\\ 0 & 1 & 0\end{bmatrix}$ are $\lambda_1 = 0$, $\lambda_2 = 1$, and $\lambda_3 = -2$.

The corresponding eigenvectors are

Ⓐ $K_1=\begin{pmatrix}0\\0\\1\end{pmatrix}$, $K_2=\begin{pmatrix}-1\\0\\1\end{pmatrix}$, $K_3=\begin{pmatrix}1\\2\\1\end{pmatrix}$　　Ⓑ $K_1=\begin{pmatrix}1\\0\\1\end{pmatrix}$, $K_2=\begin{pmatrix}-1\\1\\1\end{pmatrix}$, $K_3=\begin{pmatrix}1\\2\\-1\end{pmatrix}$

Ⓒ $K_1=\begin{pmatrix}0\\0\\1\end{pmatrix}$, $K_2=\begin{pmatrix}-1\\1\\1\end{pmatrix}$, $K_3=\begin{pmatrix}1\\2\\-1\end{pmatrix}$　　Ⓓ $K_1=\begin{pmatrix}1\\0\\1\end{pmatrix}$, $K_2=\begin{pmatrix}-1\\1\\1\end{pmatrix}$, $K_3=\begin{pmatrix}1\\2\\1\end{pmatrix}$

2. If $F(x,y,z)=xy^2+3x^2-z^3$, the gradient at point (2, -1, 4) is

Ⓐ $\nabla F(2,-1,4)=-13\bar{i}-4\bar{j}-48\bar{k}$　　Ⓑ $\nabla F(2,-1,4)=13\bar{i}+4\bar{j}-48\bar{k}$

Ⓒ $\nabla F(2,-1,4)=13\bar{i}-4\bar{j}-48\bar{k}$　　Ⓓ $\nabla F(2,-1,4)=13\bar{i}-4\bar{j}+48\bar{k}$

3. The inverse Laplace transform of $\dfrac{s^2+6s+9}{(s-1)(s-2)(s+4)}$ is

Ⓐ $\frac{16}{5}e^{t}+\frac{25}{6}e^{2t}+\frac{1}{30}e^{-4t}$　　Ⓑ $-\frac{16}{5}e^{t}+\frac{25}{6}e^{2t}-\frac{1}{30}e^{-4t}$

Ⓒ $\frac{16}{5}e^{t}-\frac{25}{6}e^{2t}+\frac{1}{30}e^{-4t}$　　Ⓓ $-\frac{16}{5}e^{t}+\frac{25}{6}e^{2t}+\frac{1}{30}e^{-4t}$

4. The Fourier series of $f(x)=\begin{cases}0,\ldots\ldots -\pi<x<0\\ \pi-x,\ldots 0\le x<\pi\end{cases}$ is

Ⓐ $f(x)=\frac{\pi}{4}-\sum_{n=1}^{\infty}\left\{\frac{1-(-1)^n}{n^2\pi}\cos nx+\frac{1}{n}\sin nx\right\}$

Ⓑ $f(x)=\frac{\pi}{4}+\sum_{n=1}^{\infty}\left\{\frac{1-(-1)^n}{n^2\pi}\cos nx-\frac{1}{n}\sin nx\right\}$

(背面仍有題目,請繼續作答)

© $f(x)=\frac{\pi}{4}-\sum_{n=1}^{\infty}\left\{\frac{1-(-1)^n}{n^2\pi}\cos nx-\frac{1}{n}\sin nx\right\}$

Ⓓ $f(x)=\frac{\pi}{4}+\sum_{n=1}^{\infty}\left\{\frac{1-(-1)^n}{n^2\pi}\cos nx+\frac{1}{n}\sin nx\right\}$

5. For $\frac{d\tau_{xz}}{dx}=A$ and $\tau_{xz}=-\eta\frac{dV_z}{dx}$. It is also known that at $x=0$, $\tau_{xz}=0$. And at $x=\delta$, $V_z=0$. Please find V_z as a function of x.

Ⓐ $V_z=-\eta Ax^2+\eta A\delta^2$　　Ⓑ $V_z=\eta Ax^2-\eta A\delta^2$

© $V_z=-\frac{A}{2\eta}x^2+\frac{A}{2\eta}\delta^2$　　Ⓓ $V_z=\frac{A}{2\eta}x^2-\frac{A}{2\eta}\delta^2$

6. Between $x=0$ and $x=\delta$, $V_z=\eta\rho g\delta^2\cos\beta\left[1-\left(\frac{x}{\delta}\right)^2\right]$. Please find the average velocity, $\overline{V_z}$, where $\overline{V_Z}=\frac{1}{\delta}\int_0^{\delta}V_z dx$.

Ⓐ $\overline{V_z}=\eta\frac{1}{2}\rho g\delta^3\cos\beta$　　Ⓑ $\overline{V_z}=\eta\frac{1}{3}\rho g\delta^3\cos\beta$

© $\overline{V_z}=\eta\frac{1}{3}\rho g\delta^2\cos\beta$　　Ⓓ $\overline{V_z}=\eta\frac{2}{3}\rho g\delta^3\cos\beta$

7. For the following equation $\frac{\partial V_x}{\partial t}+\frac{\partial(V_xV_x)}{\partial x}+\frac{\partial(V_xV_y)}{\partial y}+\frac{\partial(V_xV_z)}{\partial z}=A$, it is known that $\frac{\partial(V_x)}{\partial x}+\frac{\partial(V_y)}{\partial y}+\frac{\partial(V_z)}{\partial z}=0$. Then, the original equation can be rewritten as

Ⓐ $\frac{\partial V_x}{\partial t}+V_x\frac{\partial V_x}{\partial x}+V_y\frac{\partial V_x}{\partial y}+V_z\frac{\partial V_x}{\partial z}=A$

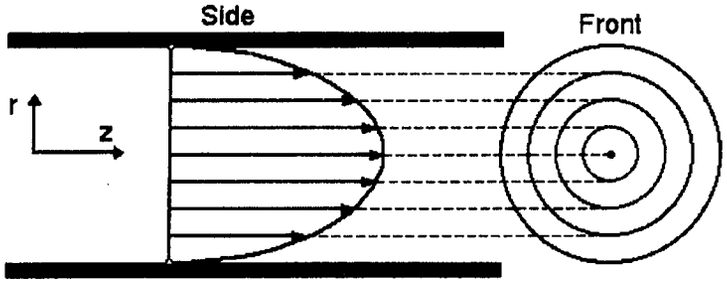
Ⓑ $\frac{\partial V_x}{\partial t}+\frac{\partial V_x}{\partial x}+\frac{\partial V_x}{\partial y}+\frac{\partial V_x}{\partial z}=A$

© $\frac{\partial V_x}{\partial t}+V_x^2\frac{\partial V_x}{\partial x}+V_y^2\frac{\partial V_x}{\partial y}+V_z^2\frac{\partial V_x}{\partial z}=A$

Ⓓ $\frac{\partial V_x}{\partial t}+\frac{1}{V_x}\frac{\partial V_x}{\partial x}+\frac{1}{V_y}\frac{\partial V_x}{\partial y}+\frac{1}{V_z}\frac{\partial V_x}{\partial z}=A$

8. A pressure flow is given inside a cylinder (see in the figure). Velocity profile based on a

Newtonian fluid is developed as $V(r) = \frac{\Delta P R^2}{4\mu L}\left[1 - \left(\frac{r}{R}\right)^2\right]$, where ΔP is the pressure gradient, R is the inner radius of the cylinder, μ is the Newtonian viscosity, and L is the length of the cylinder. So, what is the flow rate in this case?



Ⓐ $\frac{\Delta P R^2}{4\mu L} \times \pi R^2$　　Ⓑ $\frac{\Delta P R^2}{8\mu L} \times \pi R^2$

Ⓒ $\frac{\Delta P R^2}{4\mu L} \times \pi$　　Ⓓ $\frac{\Delta P R^2}{8\mu L} \times \pi$

9. A point P in the spherical coordinate is labeled as (r, θ, ϕ). It can be also represented in the cylindrical coordinates as (r', θ', z). Which of the following equations is CORRECT:

Ⓐ $\theta \neq \theta'$　　Ⓑ $r \neq r'$

Ⓒ $z = r \tan\phi$　　Ⓓ $\sin\theta' = \cos\phi$

10. Which one of the following four points is not in the same plane with other three:

Ⓐ (1, 1, -3)　　Ⓑ (2, 2, -3)

Ⓒ (7, 4, 0)　　Ⓓ (5, 8, 2)

（背面仍有題目，請繼續作答）

科目名稱：　材料力學

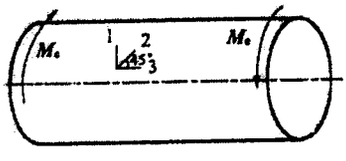
每題為 4 選 1，每一題答對得 3 分，答錯倒扣 0.75 分。

11. Ⓐ Mohr's　Ⓑ Euler's　Ⓒ Rankine's　Ⓓ Saint-Venant's principle has great practical significance in the design and analysis of bars, beams, shafts, and other structures encountered in mechanics of materials. Because the effects of stress concentrations are localized, so we can use the standard stress formula (such as P/A) at cross sections a sufficient distance away from the source of the concentration.

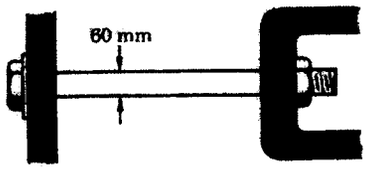
12. The normal stress acting on the cross section through the center of the circular hole has a specific stress distribution. The maximum stress occurs at the edges of the hole and may be significantly larger than the normal stress at the same cross section. The intensity of a stress concentration is usually expressed by a ratio that equals
Ⓐ 1　Ⓑ 3　Ⓒ 5　Ⓓ 7

13. As determined by an axial tension or axial compression test of the same material, the maximum-shear- stress theory predicts failure of a specimen subjected to any combination of loads when the maximum shear stress at any point reaches the failure stress equal to
Ⓐ 1　Ⓑ 1/2　Ⓒ 1/3　Ⓓ 2
of the normal stress.

14. During a test of torsion on a beam, the strain gages of 1, 2 and 3 are mounted on the surface of the tested beam as shown in the following figure. What are the readings of the strain gage almost zero?
Ⓐ 1 and 2　Ⓑ 2 and 3　Ⓒ 1 and 3　Ⓓ 1, 2 and 3

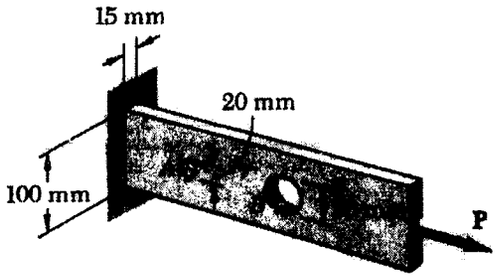


15. The change in diameter of a large steel bolt is carefully measured as the nut is tightened as shown in the following figure. Knowing that E = 200 GPa and υ = 0.30, determine the internal force in the bolt, if the diameter is observed to shorten by 15μm.
Ⓐ -207.3N　Ⓑ 108.9N　Ⓒ 392.7N　Ⓓ 457.7N



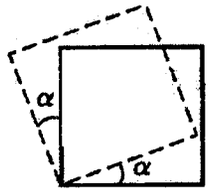
16. Two holes have been drilled through a long steel bar which is subjected to a centric axial load as shown in the following figure. For P = 32 kN, determine the maximum value of the stress at A.

Ⓐ -40.3 MPa　Ⓑ 65.1 MPa　Ⓒ 85.7 MPa　Ⓓ -75.5 MPa.



17. After deformation the original element which is rectangle is changed as shown in the following figure by dash lines. Determine the shear strain.

Ⓐ $\gamma = 0$　Ⓑ $\gamma = \alpha$　Ⓒ $\gamma = -\alpha$　Ⓓ $\gamma = 2\alpha$.



18. What is the best way to enhance the **torsional rigiditiy** of a bar of carbon steels under torsion?

Ⓐ reduce the length of the bar
Ⓑ use high strength steels
Ⓒ improve the surface roughness of the bar
Ⓓ increase the diameter of the bar.

19. A prismatic bar of Young's modulus (modulus of elasticity) E, length L and cross-sectional area A is extended elastically by axial load P. The extension (δL) of the bar is

Ⓐ $P\,L/A\,E$　Ⓑ $P\,E/A\,L$　Ⓒ $P\,L\,E/A$　Ⓓ $A\,L/P\,E$.

20. The tensile flow curve of a material obeys the power law $\sigma = k\,\varepsilon^n$, where σ and ε are the true tensile stress and true tensile strain, and k and n are two constants. Necking of the specimen will start to occur at a strain when the slope of the flow curve is equal to the stress at that strain. What is this onset strain of necking?

Ⓐ kn　Ⓑ n/k　Ⓒ n　Ⓓ $1+n$.

（背面仍有題目，請繼續作答）

科目名稱：　材料科學導論

每題為 4 選 1，每一題答對得 1 分，答錯倒扣 0.25 分。

21. The equilibrium number of vacancies per cubic meter for copper at 1000℃ is

Ⓐ 2.2×10^{10}　Ⓑ 2.2×10^{15}　Ⓒ 2.2×10^{20}　Ⓓ 2.2×10^{25}

The energy for vacancy formation is 0.9 eV/atom; the atomic weight and density for copper are 63.5 g/mol and 8.40 g/cm^3, respectively.

22. What Schottky defects can exist in $BaTiO_3$?

Ⓐ V_{Ba}''　Ⓑ $V_O^{\cdot\cdot}$　Ⓒ V_{Ti}''''　Ⓓ all of the above.

23. Dislocations

Ⓐ are line defects

Ⓑ cause slip between crystal plane when they move

Ⓒ produce permanent deformation in metals, ceramics and polymeric materials

Ⓓ all of the above.

24. Grain boundaries

Ⓐ are produced by the solidification process

Ⓑ have a change in crystal orientation across them

Ⓒ impede dislocation motion

Ⓓ all of the above.

25. Calculate the percent cold reduction after cold rolling 0.102 cm-thick aluminum sheet to 0.063 cm.

Ⓐ 3.82 %　Ⓑ 3.90 %　Ⓒ 38.2 %　Ⓓ 39.0 %.

26. In the

Ⓐ forging process　Ⓑ hammer forging　Ⓒ press forging　Ⓓ forming process, metal is hammered or pressed into the desired shape.

27. Calculate the engineering stress in SI units on a bar 25 cm long and having a cross section of 9.00 mm × 4.00 mm that is subjected to a load of 3500 kg.

Ⓐ 97.2 Pa　Ⓑ 954 Pa　Ⓒ 97.2 MPa　Ⓓ 954 MPa.

28. The diffusion coefficients for copper in aluminum at 500 and 600℃ are 4.15×10^{-14} and

4.69×10^{-13} m^2/s, respectively. What time will be required at 500℃ to produce the same diffusion result as for 20 h at 600℃?

Ⓐ 110 h　Ⓑ 113 h　Ⓒ 220 h　Ⓓ 226 h.

29. The modulus of elasticity for spinel having 5 vol% porosity is 240 GPa. Compute the modulus of elasticity for the nonporous material.

Ⓐ 252 GPa　Ⓑ 253 GPa　Ⓒ 265 GPa　Ⓓ 270 GPa.

30. A typical dislocation density for ceramic materials is

Ⓐ $10^9\sim10^{10}$ mm^{-2}　Ⓑ $10^5\sim10^6$ mm^{-2}　Ⓒ $10^2\sim10^4$ mm^{-2}　Ⓓ $10^{-1}\sim10^1$ mm^{-2}

31. A reaction wherein, upon cooling, a solid and a liquid phase transform isothermally and reversibly to a solid phase having a different composition is called

Ⓐ hypereutectoid　Ⓑ eutectic　Ⓒ eutectoid　Ⓓ peritectic reaction.

32. A two-phase microstructure found in some steels and cast irons; it results from the transformation of austenite of eutectoid composition and consists of alternating layers of ferrite and cementite is called

Ⓐ bainite　Ⓑ spheroidite　Ⓒ pearlite　Ⓓ austenite.

33. For corrosion resistance to moderate oxidizing conditions, alloys containing

Ⓐ titanium　Ⓑ nickel　Ⓒ silicon　Ⓓ chromium

are used.

34. In the SI system, electrical conductivity is expressed in

Ⓐ ohm-meters　Ⓑ $(\text{ohm-meters})^{-1}$　Ⓒ ohm/meter　Ⓓ meter/ohm.

35. The units of engineering stress are

Ⓐ psi　Ⓑ MPa　Ⓒ N/m^2　Ⓓ all of the above.

36. To obtain a high fracture toughness with an interlocking grain microstructure, the Si_3N_4 starting powder used for sintering should be the phase of

Ⓐ α　Ⓑ β　Ⓒ ν　Ⓓ $\in$

37. In Fe_3O_4 compound, we have the point defects of

Ⓐ Fe vacancy　Ⓑ Fe interstitial　Ⓒ O vacancy　Ⓓ O interstitial.

38. Brick is a product obtained by firing the clay. It has a higher strength as containing

Ⓐ spinel　Ⓑ alumina　Ⓒ silica　Ⓓ mullite
in microstructure.

39. Thermoplastic polymers softer when heated and harden when cooled-processes that are totally reversible and may be repeated. They are classified as green materials and can be recycled. In the following polymers which one is thermoplastic
Ⓐ polyethylene　Ⓑ vulcanized　Ⓒ epoxy　Ⓓ phenolic.

40. Teflon has a structure of variant polyethylene, in which all hydrogen atoms are replaced with
Ⓐ Cl　Ⓑ Br　Ⓒ F　Ⓓ S

41. The liquid crystal polymers with
Ⓐ smectic　Ⓑ nematic　Ⓒ cholesteric　Ⓓ styrenic
type are used in LCD for TV, digital watches, laptop computers, and other digital displays.

42. Carbon fiber-reinforced polymer composites are currently being utilized extensively in sports and recreational equipment like bicycle. The structure of carbon fibers used is
Ⓐ diamond-like
Ⓑ graphitic
Ⓒ diamond-like with some amorphous regions
Ⓓ graphitic with some amorphous region.

43. An electrochemical cell consists of iron electrodes, one of which is immersed in a solution with flowing O_2, the other is immersed in a solution with flowing N_2. In this case, the anode is
Ⓐ Fe in solution with O_2
Ⓑ Fe in solution with N_2
Ⓒ both Fe could be anode
Ⓓ the cell will not function due to same potential.

44. The resistivity of metal would not be increased by
Ⓐ temperature decrease　Ⓑ impurity addition
Ⓒ cold work　Ⓓ alloying.

45. At low voltages a varistor is ohmic, but above a certain threshold or breakdown voltage, large amounts of current are passed and the apparent resistivity becomes extremely low. Hence, it can be used as a surge protector connected in parallel with the device to be protected. The material widely used as varistors is
Ⓐ SiO_2　Ⓑ MgO　Ⓒ ZrO_2　Ⓓ ZnO.

46. Thermal conductivity is an important issue in optical-electronic devices. In the following, which one of the materials has the highest themal conductivity coefficient
Ⓐ copper　Ⓑ aluminum　Ⓒ graphite　Ⓓ diamond.

47. The shape of the B-H loop characterizes whether a magnet is hard or soft and determines their applications. Square loop ferrites show sharply discontinuous changes in B at the coercive field and are useful in
Ⓐ sensor　Ⓑ actuator
Ⓒ transformer cores　Ⓓ magnetic storage media.

48. Magnetic ceramic materials like Fe_3O_4 have structure of
Ⓐ perovskite　Ⓑ fluorite　Ⓒ inverse spinel　Ⓓ normal spinel.

49. The wavelength for visible light is about 0.4μm, the energy gap of materials possible to absorb visible light is about
Ⓐ 6.1eV　Ⓑ 5.1eV　Ⓒ 4.1eV　Ⓓ 3.1eV
(if $C=3\times10^8$ m/s, $h=4.13\times10^{-15}$ eV-s).

50. At present, all telecommunications are transmitted via optical fiber with species of
Ⓐ electrons　Ⓑ photons　Ⓒ holes　Ⓓ phonons
for improving speed of transmission, information density, and transmission distance with a reduction in error rate and interference.