PhD comprehensive Exam Examples:

ت	المادة	Subject
1	الرياضيات الهندسية المتقدمة	Advanced Engineering Mathematics
2	الاهتزازات الميكانيكية المتقدمة	Advanced Mechanical Vibrations
3	مرونة	Elasticity
4	انتقال الحرارة متقدم	Advanced Heat Transfer
5	ديناميك الحرارة متقدم	Advanced Thermodynamics
6	مواد هندسية متقدمة	Advanced Engineering Materials
7	عمليات سباكة متقدمة	Advanced Casting Process

Advanced Engineering Mathematics

Some Problems

1. By using techniques involving the Gamma function, find the value of:

$$\int_0^\infty x^3 e^{-\frac{1}{2}x^2}\,dx$$

2. By using techniques involving the Gamma function, find the value of:

$$\int_0^1 [\ln x]^n\,dx$$

3. Use the definition of Gamma functions, show that:

$$\Gamma(m+\tfrac{1}{2}) \equiv \frac{(2m)!\sqrt{\pi}}{2^{2m}m!}$$

4. Use the definition of Beta and Gamma functions, show that:

$$\int_0^1 (1-\sqrt{x})^n\,dx = \frac{2}{(n+2)(n+1)}$$

$$\text{Let } u^2 = x$$

5. Use the definition of Beta and Gamma functions, show that:

$$\int_0^{\frac{\pi}{2}} \sqrt{tan\,\theta}\,d\theta = \frac{\pi}{\sqrt{2}}$$

6. Use the definition of Beta and Gamma functions, show that:

$$\int_{-1}^{1} \frac{(1+x)}{(1-x)} dx$$

Let $x = 2t - 1$

7. Find the general solution of the following differential equations:

8. $x^2 y'' + xy' + (x^2 - 9)y = 0$

9. Show that the differential equation

$$\sin\theta \frac{d^2\theta}{d\theta^2} + \cos\theta \frac{dy}{d\theta} + n(n+1)(\sin\theta)y = 0$$

can be transformed into Legendre's equation by means of the substitution $x = cos\theta$

10. Find the general solution of the given second-order differential equation:

$$y'' - y' - 6y = 0$$

11. Solve the given initial-value problem:

$$y'' + 16y = 0, \quad y(0) = 2, \quad y'(0) = -2$$

12. Solve the given boundary-value problem:

$$y'' + y = 0, \quad y'(0) = 2, \quad y'\left(\tfrac{\pi}{2}\right) = 0$$

13. Find the Wronskian of the given second-order differential equation:

$$y'' - 4y' + 4y = (x+1)e^{2x}$$

14. Solve the initial-value problem:

$$4x^2 y'' + 17y = 0, \quad y(1) = -1, \quad y'(1) = -\tfrac{1}{2}$$

15. Find the general solution of the given second-order differential equation:

$$x^2 y'' - 2xy' - 4y = 0$$

16. Find the general solution of the given second-order differential equation:

$$4x^2 y'' + 8xy' + y = 0$$

17. Show that the set of functions

$$1, \sin\frac{\pi x}{L}, \cos\frac{\pi x}{L}, \sin\frac{2\pi x}{L}, \cos\frac{2\pi x}{L}, \sin\frac{3\pi x}{L}, \cos\frac{3\pi x}{L}, \dots \sin\frac{n\pi x}{L}, \cos\frac{n\pi x}{L}, \dots$$

Forms an orthogonal set in the interval $(-L, L)$.

18. Find the non-trivial solutions of the boundary-value problem $y'' + \lambda y = 0$, $y'(0) = 0$ and $y'(1) = 0$

19. Classify the following PDEs in terms of linearity and homogeneity:

a. $\frac{\partial^2 u}{\partial x^2} + (\frac{\partial^2 u}{\partial x \partial y})^2 + \frac{\partial^2 u}{\partial y^2} = tanx$

b. $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = tanx$

c. $\frac{\partial^2 u}{\partial x^2} + (\frac{\partial^2 u}{\partial x \partial y})^2 + \frac{\partial^2 u}{\partial y^2} = 0$

d. $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$

20. Solve the initial value problem $y'' + x^2 y = 0$ with $y(0) = 0$ and $y'(0) = 0$

Advanced Mechanical Vibrations

المجموعة الولى

1. The system shown in Figure (1), has

a- One generalized coordinate

b- Two generalized coordinate

c- Three generalized coordinate

d- Four generalized coordinate

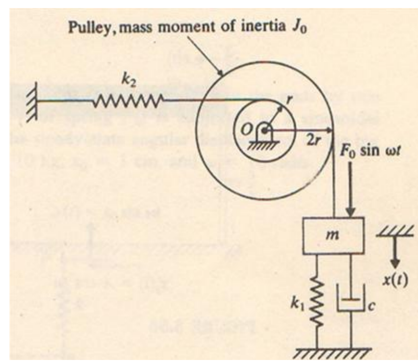


Figure (1)

2. The Spherical Pendulum shown in Figure (2), has

a- One generalized coordinate

b- Two generalized coordinate

c- Three generalized coordinate

d- Four generalized coordinate

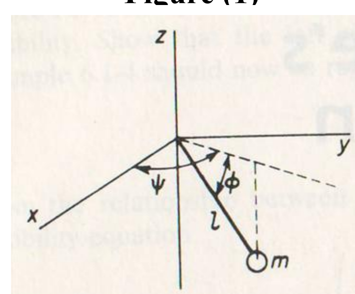


Figure (2)

3. The Double Pendulum shown in Figure (3), has

a- One generalized coordinate

b- Two generalized coordinate

c- Three generalized coordinate

d- Four generalized coordinate

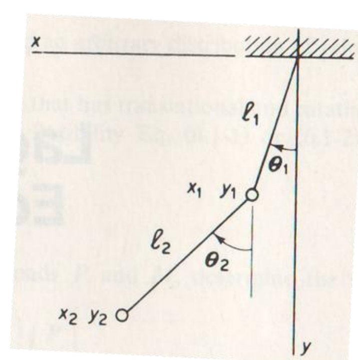


Figure (3)

4. The system shown in Figure (4), has

a- One generalized coordinate

b- Two generalized coordinate

c- Three generalized coordinate

d- Four generalized coordinate

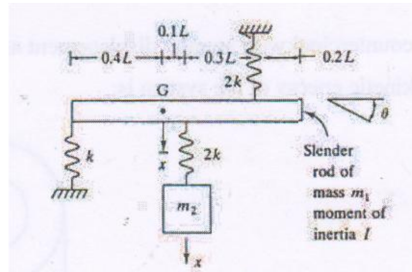


Figure (4)

المجموعة الثانية

5. The Equation of motion for the 12 kg mass shown in Figure (5) is $x(t) = Ce^{-\zeta\omega_n t}\cos(\omega_d t - \phi)$. If the mass 12 kg is released from rest at a distance x_o to the left of the equilibrium position. Then the constant C is

a- $1.265x_o$

b- $2.653x_o$

c- $1.755x_o$

d- $3.78x_o$

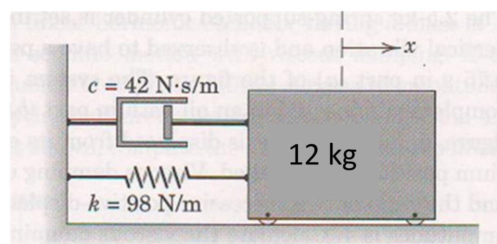


Figure (5)

6. The Equation of motion for the 12 kg mass shown in Figure (6) is $x(t) = Ce^{-\zeta\omega_n t}\cos(\omega_d t - \phi)$. If the mass 12 kg is released from rest at a distance x_o to the left of the equilibrium position. Then the constant ϕ is

a- 45°

b- 61.9°

c- 25.4°

d- 37.77°

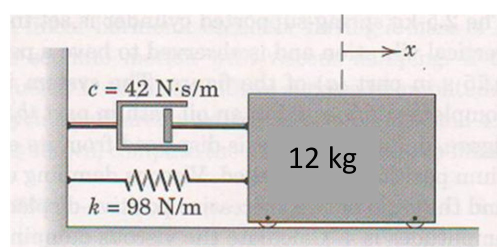


Figure (6)

7. The Equation of motion for the 8 kg mass shown in Figure (7) is $x(t) = Ce^{-\zeta\omega_n t}\cos(\omega_d t - \phi)$. if the viscous damping constant c of 20 $\mathrm{N.sec/m}$, and stiffness k of spring is 32 $\mathrm{N/m}$. Then the constant ϕ is

a- 45°

b- 38.68°

c- 25.4°

d- 67.77°

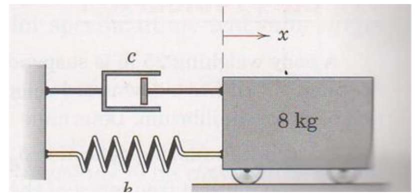


Figure (7)

8. The Equation of motion for the 8 kg mass shown in Figure (8) is $x(t) = Ce^{-\zeta\omega_n t}\cos(\omega_d t - \phi)$. if the viscous damping constant c of 20 $\mathrm{N.sec/m}$, and stiffness k of spring is 32 $\mathrm{N/m}$. Then the constant C is

a- 0.59 m

b- 0.256 m

c- 0.369 m

d- 0.61 m

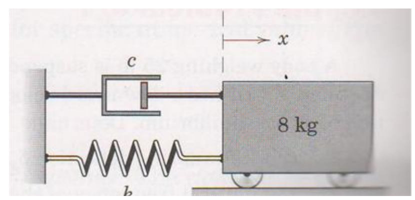


Figure (8)

المجموعة الثالثة

9. If θ and $\dot{\theta}$ are counterclockwise angular displacement and angular velocity of the disk in Figure (9). Then the kinetic energy of the system is:

a- $1.25\dot{\theta}^2$ $\mathrm{kg.m^2}$

b- $2.25\dot{\theta}^2$ $\mathrm{kg.m^2}$

c- $4.25\dot{\theta}^2$ $\mathrm{kg.m^2}$

d- $5.25\dot{\theta}^2$ $\mathrm{kg.m^2}$

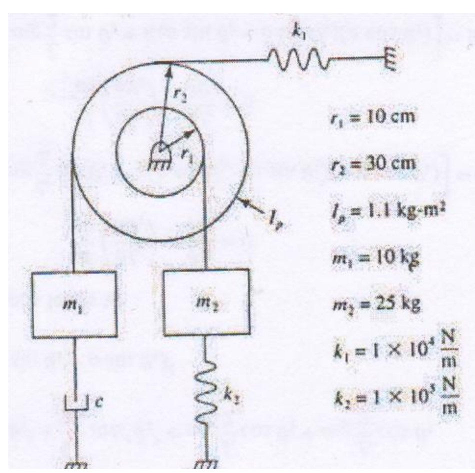


Figure (9)

10. The potential energy of the system shown in Figure (10) at an arbitrary instant θ_1 and θ_2 is

a- $-mg\frac{L}{2}\sin\theta_1 - mg\frac{L}{2}\sin\theta_2 + \frac{1}{2}k(a\cos\theta_2 - a\cos\theta_1)^2$

b- $-mgL\cos\theta_1 - mgL\cos\theta_2 + \frac{1}{2}k(\frac{a}{2}\sin\theta_2 - \frac{a}{2}\sin\theta_1)^2$

c- $-mg\frac{L}{2}\cos\theta_1 - mg\frac{L}{2}\cos\theta_2 + \frac{1}{2}k(a\sin\theta_2 - a\sin\theta_1)^2$

d- $-mga\cos\theta_1 - mga\cos\theta_2 + \frac{1}{2}k(L\sin\theta_2 - L\sin\theta_1)^2$

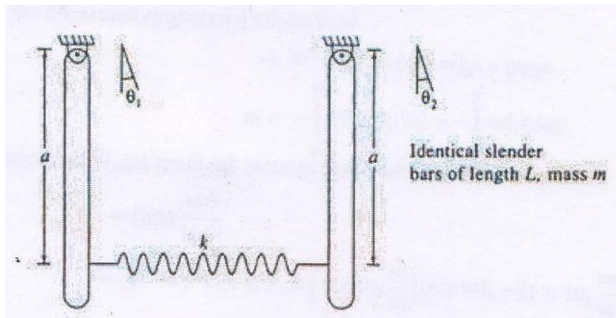


Figure (10)

11. The kinetic energy of the system sown in Figure (11) at an arbitrary instant is

$(a) -$ $\frac{1}{2}m\dot{x}^2 + \frac{1}{2}2m(\dot{x} + \frac{1}{2}L\dot{\theta})^2 + \frac{1}{2}\frac{1}{12}2mL^2\dot{\theta}^2$

$(b) -$ $\frac{1}{2}m\dot{x}^2 + (\frac{1}{2}L\dot{\theta})^2 + \frac{1}{2}\frac{1}{12}2mL^2\dot{\theta}^2$

$(c) -$ $\frac{1}{2}m\dot{x}^2 + \frac{1}{2}2m(\dot{x} + \frac{1}{2}L\dot{\theta})^2$

$(d) -$ $\frac{1}{2}2m(\dot{x} + \frac{1}{2}L\dot{\theta})^2 + \frac{1}{2}\frac{1}{12}$

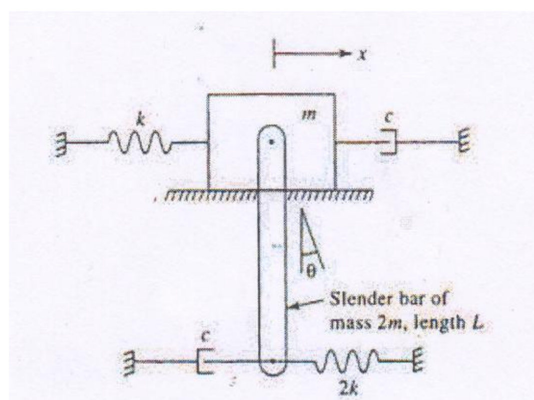
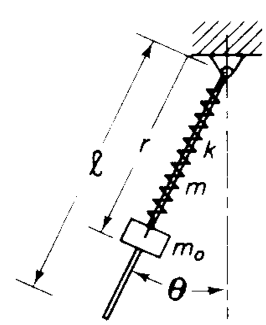


Figure (11)

12. The rod of mass m which carries the collar of mass m_0 shown in Figure (12) rotates with angular velocity $\dot{\theta}$. If the spring has unstretched length r_0 then the total kinetic energy of the



system at the position shown is [neglect the friction between the rod and collar]

$(a) -$ $\frac{1}{2}m_0(r\dot{\theta})^2 + \frac{1}{2}m(\dot{r})^2$

$(b) -$ $\frac{1}{2}m_0(r\dot{\theta})^2 + \frac{1}{2}m_0(\dot{r})^2 + \frac{1}{2}(m\frac{l^2}{3})(\dot{\theta})^2$

Figure (12)

$(c) -$ $m_0(\dot{r})^2 + \frac{1}{2}(m\frac{l^2}{3})(\dot{r})^2$

$(d) -$ $\frac{1}{2}m_0(r\dot{\theta})^2 + \frac{1}{2}(m\frac{l^2}{3})(\dot{\theta})^2$

13. The potential energy of the system sown in Figure (13) at an arbitrary instant is

$(a) -$ $\frac{1}{2}kx^2 + \frac{1}{2}2k(x + L\theta)^2$

$(b) -$ $\frac{1}{2}kx^2 + \frac{1}{2}2k(x)^2 - 2mg\frac{L}{2}\cos\theta$

$(c) -$ $\frac{1}{2}kx^2 + \frac{1}{2}2k(x + L\theta)^2 - 2mg\frac{L}{2}\cos\theta$

$(d) -$ $\frac{1}{2}kx^2 + \frac{1}{2}2k(x + L\theta)^2 - 2mg\frac{L}{2}\cos\theta + \frac{1}{2}c\dot{x}^2 + \frac{1}{2}c\left(\dot{x} + L\dot{\theta}\right)^2$

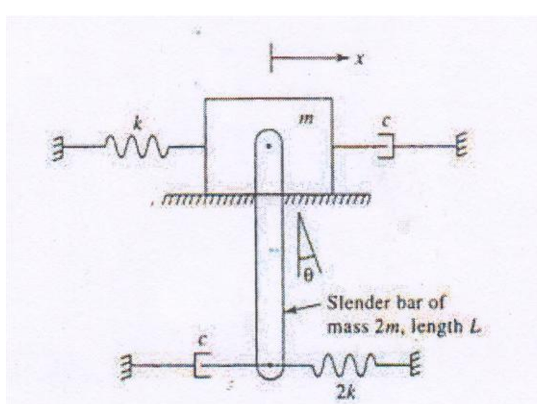


Figure (13)

14. The system in Figure (14) of two rigid rods of mass m for each. At the position shown the total potential energy of the system is

$(a) -\ \frac{1}{2}k(\frac{l}{2}\theta_1)^2$

$(b) -\ \frac{1}{2}k(\frac{l}{2}\theta_1)^2 + mg\frac{l}{2}(1-\cos\theta_1) + mg[l(1-\cos\theta_1) + \frac{l}{2}(1-\cos\theta_2)]$

$(c) -\ \frac{1}{2}k(\frac{l}{2}\theta_1)^2 + +mg[l(1-\cos\theta_1) + \frac{l}{2}(1-\cos\theta_2)]$

$(d) -\ \frac{1}{2}k(\frac{l}{2}\theta_1)^2 + mg\frac{l}{2}(1-\cos\theta_1) + mg[l(1-\cos\theta_1)]$

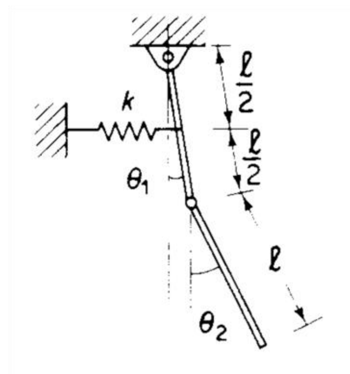


Figure (14)

المجموعة الرابعة

15. If the differential equations governing the motion of a system are

$$\begin{bmatrix} m & 0 \\ 0 & m \end{bmatrix}\begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} 2k & -k \\ -k & 3k \end{bmatrix}\begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

then the natural frequencies of the system are

a- $\omega_1 = 2.23\sqrt{\frac{k}{m}}$, $\omega_2 = 4.12\sqrt{\frac{k}{m}}$

b- $\omega_1 = 1.176\sqrt{\frac{k}{m}}$, $\omega_2 = 1.902\sqrt{\frac{k}{m}}$

c- $\omega_1 = 3.76\sqrt{\frac{k}{m}}$, $\omega_2 = 5.36\sqrt{\frac{k}{m}}$

d- $\omega_1 = 5.82\sqrt{\frac{k}{m}}$, $\omega_2 = 6.97\sqrt{\frac{k}{m}}$

16. If the equations of motion of a two degree of freedom system are given by

$$\underbrace{\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix}}_{M} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \underbrace{\begin{bmatrix} k_1 & k_1 \\ k_1 & k_1+k_2 \end{bmatrix}}_{K} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

in which $m_1 = \frac{1}{2} m_2$ and $k_1 = \frac{1}{2} k_2$, then, the natural frequencies of the system are

$(a) -$ $\omega_1^2 = \frac{1}{2}\frac{k_1}{m_1}$, $\omega_2^2 = 2\frac{k_1}{m_1}$

$(b) -$ $\omega_1^2 = \frac{1}{3}\frac{k_1}{m_1}$, $\omega_2^2 = 3\frac{k_1}{m_1}$

$(c) -$ $\omega_1^2 = \frac{3}{2}\frac{k_1}{m_1}$, $\omega_2^2 = \frac{2}{3}\frac{k_1}{m_1}$

$(d) -$ $\omega_1^2 = \frac{1}{4}\frac{k_1}{m_1}$, $\omega_2^2 = 4\frac{k_1}{m_1}$

المجموعة الخامسة (اسئلة متفرقة)

17. If a single degree of freedom system is excited by impulsive force at $t = 0$. Then the initial conditions of the system are

$(a) -$ $y_0 = \frac{1}{k}$ $\dot{y}_0 = 0$

$(b) -$ $y_0 = 0$ $\dot{y}_0 = \frac{1}{m}$

$(c) -$ $y_0 = \frac{1}{m}$ $\dot{y}_0 = 0$

$(d) -$ $y_0 = 0$ $\dot{y}_0 = \frac{1}{k}$

18. If the differential equations governing the motion of a system are

$$\begin{bmatrix} 100 & 60 \\ 60 & 120 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} 30000 & -10000 \\ -10000 & 20000 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

and the natural frequencies of the system are $\omega_1 = 9.044 \text{ rad/sec}$, $\omega_2 = 26.98 \text{ rad/sec}$

then the second normal mode is

a- $[1 \quad 0.8]^T$
b- $[1 \quad 0.6]^T$
c- $[1 \quad -0.8]^T$
d- $[1 \quad -0.6]^T$

19. The mass and stiffness matrices for the two-degree-of-freedom system are given by

$$\mathbf{M} = m\begin{bmatrix}1 & 0\\0 & 2\end{bmatrix}, \quad \mathbf{K} = \frac{T}{L}\begin{bmatrix}2 & -1\\-1 & 3\end{bmatrix}$$

and corresponding second orthonormal modal matrix are

$$\mathbf{u}_2 = \alpha\begin{bmatrix}1\\-0.5\end{bmatrix}$$

then α should be

a- $\frac{1}{\sqrt{1.5m}}$

b- $\frac{1}{\sqrt{2m}}$

c- $\frac{1}{\sqrt{2.5m}}$

d- $\frac{1}{\sqrt{3.5m}}$

20. The Lagrange's equations $\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_k}\right) - \frac{\partial T}{\partial q_k} + \frac{\partial V}{\partial q_k} = Q_k$ is used to find

$(a) -$ Modal matrix

$(b) -$ Equation of motion

$(c) -$ Natural frequencies of the system

$(d) -$ Free response of the system

21. If the mass and stiffness matrices for the two-degree-of-freedom system are given by

$$\mathbf{M} = m\begin{bmatrix}1 & 0\\0 & 2\end{bmatrix}, \quad \mathbf{K} = k\begin{bmatrix}2 & -1\\-1 & 3\end{bmatrix}$$

and corresponding modal matrix are

$$\phi_1 = \begin{bmatrix}1\\1\end{bmatrix} \quad , \quad \phi_2 = \begin{bmatrix}1\\-0.5\end{bmatrix}$$

Then the orthonormal modes are

$(a) -$ $\frac{1}{\sqrt{m}}\begin{bmatrix}\sqrt{\frac{2}{3}}\\\sqrt{\frac{2}{3}}\end{bmatrix}$, $\frac{1}{\sqrt{m}}\begin{bmatrix}\sqrt{\frac{2}{3}}\\-\sqrt{\frac{2}{3}}\end{bmatrix}$

$(b) -$ $\frac{1}{\sqrt{m}}\begin{bmatrix}\frac{1}{\sqrt{3}}\\\frac{1}{\sqrt{3}}\end{bmatrix}$, $\frac{1}{\sqrt{m}}\begin{bmatrix}\sqrt{\frac{2}{3}}\\-\sqrt{\frac{2}{12}}\end{bmatrix}$

(c) − $\frac{1}{\sqrt{m}}\begin{bmatrix}\sqrt{3}\\ \sqrt{3}\end{bmatrix}$, $\frac{1}{\sqrt{m}}\begin{bmatrix}\sqrt{\frac{3}{2}}\\ -\sqrt{\frac{3}{1}}\end{bmatrix}$

(d) − $\frac{1}{\sqrt{m}}\begin{bmatrix}1\\ 1\end{bmatrix}$, $\frac{1}{\sqrt{m}}\begin{bmatrix}2\\ -2.5\end{bmatrix}$

22. If the mass and stiffness matrices for the two-degree-of-freedom system are given by

$$\mathbf{M} = m\begin{bmatrix}2 & 0\\ 0 & 1\end{bmatrix}, \quad \mathbf{K} = k\begin{bmatrix}3 & -1\\ -1 & 1\end{bmatrix}$$

and corresponding orthonormal modal matrix are

$$\phi_1 = \frac{1}{\sqrt{m}}\begin{bmatrix}0.4082\\ 0.8165\end{bmatrix} \quad , \quad \phi_2 = \frac{1}{\sqrt{m}}\begin{bmatrix}-0.5774\\ 0.5774\end{bmatrix}$$

Then the natural frequencies of the system are

(a) − $\omega_1 = 0.909\sqrt{\frac{k}{m}}$, $\omega_2 = 2.35\sqrt{\frac{k}{m}}$

(b) − $\omega_1 = 1.00\sqrt{\frac{k}{m}}$, $\omega_2 = 4.21\sqrt{\frac{k}{m}}$

(c) − $\omega_1 = 0.707\sqrt{\frac{k}{m}}$, $\omega_2 = 1.414\sqrt{\frac{k}{m}}$

(d) − $\omega_1 = 1.10\sqrt{\frac{k}{m}}$, $\omega_2 = 3.20\sqrt{\frac{k}{m}}$

23. If the kinetic and potential energy of the system are given by

$$T = \frac{1}{2}m\dot{q}_1 + \frac{1}{2}J\dot{q}_2^2 \quad , \quad T = \frac{1}{2}kq_1^2 + \frac{1}{2}k(rq_2 - q_1)^2$$

Then the stiffness matrix of the system is

(a) − $\begin{bmatrix}k & -kr\\ -kr & kr\end{bmatrix}$

(b) − $\begin{bmatrix}2k & kr^2\\ kr^2 & kr\end{bmatrix}$

(c) − $\begin{bmatrix}2k & -kr\\ -kr & kr^2\end{bmatrix}$

(d) − $\begin{bmatrix}k & kr^2\\ kr^2 & kr\end{bmatrix}$

24. If a system has the following properties modal matrix P of a system is

$$P = \text{modal matrix} = \begin{bmatrix} 0.731 & -2.73 \\ 1.00 & 1.00 \end{bmatrix}, [M] = \text{mass matrix} = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix},$$

$$[K] = \text{stiffness matrix} = \begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}$$

Then the generalized masses are

$(a) -$ 2.53 , 9.45

$(b) -$ 2.43 , 9.25

$(c) -$ 4.53 , 8.45

$(d) -$ 5.43 , 10.25

25. If $k_1 = k_2 = k_3 = k$, then the stiffness matrix of the system shown in Figure (15) is

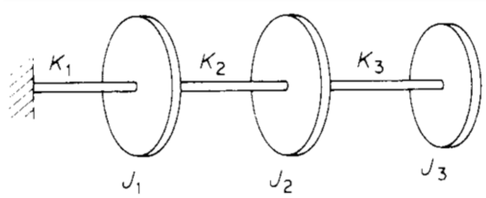


Figure (15)

$(a) -$ $k\begin{bmatrix} 1 & -1 & 0 \\ -1 & 1 & -1 \\ 0 & -1 & 1 \end{bmatrix}$

$(b) -$ $k\begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix}$

$(c) -$ $k\begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 2 \end{bmatrix}$

$(d) -$ $k\begin{bmatrix} 3 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix}$

Question Bank (Elasticity)

1. **What is the property of a material that allows it to regain its original shape after deformation?**
   - A) Plasticity
   - B) Elasticity
   - C) Ductility
   - D) Malleability

   Answer: B
2. **The ratio of stress to strain within the elastic limit is known as:**
   - A) Poisson's ratio
   - B) Young's modulus
   - C) Bulk modulus
   - D) Shear modulus

   Answer: B
3. **Which type of stress occurs when two equal and opposite forces act tangentially to a surface?**
   - A) Tensile stress
   - B) Compressive stress
   - C) Shear stress
   - D) Volumetric stress

   Answer: C
4. **In Hooke's law, stress is directly proportional to:**
   - A) Strain
   - B) Square of strain
   - C) Cube of strain
   - D) None of the above

   Answer: A
5. **The ability of a material to undergo significant plastic deformation before rupture is called:**
   - A) Elasticity
   - B) Ductility
   - C) Malleability
   - D) Brittleness

   Answer: B
6. **The modulus of rigidity is also known as:**
   - A) Young's modulus
   - B) Shear modulus
   - C) Bulk modulus
   - D) Elastic modulus

   Answer: B
7. **Which of the following materials has the highest Young's modulus?**
   - A) Rubber
   - B) Steel
   - C) Copper
   - D) Aluminum

   Answer: B
8. **The unit of Young's modulus in SI system is:**

- A) N/m
- B) N/m²
- C) N/m³
- D) N·m

  Answer: B

9. **When a material is stretched, the decrease in diameter is due to:**
   - A) Tensile stress
   - B) Compressive stress
   - C) Lateral strain
   - D) Shear strain

   Answer: C
10. **The stress at which a material breaks is called:**
    - A) Yield stress
    - B) Ultimate stress
    - C) Breaking stress
    - D) Elastic limit

    Answer: C
11. **Which of the following is not a type of stress?**
    - A) Tensile
    - B) Compressive
    - C) Shear
    - D) Torsional

    Answer: D
12. **The area under the stress-strain curve represents:**
    - A) Elastic limit
    - B) Modulus of elasticity
    - C) Toughness
    - D) Ductility

    Answer: C
13. **The strain produced in a body is:**
    - A) Directly proportional to the applied force
    - B) Inversely proportional to the applied force
    - C) Independent of the applied force
    - D) None of the above

    Answer:
14. **Which of the following materials is most likely to have a Poisson's ratio close to 0.5?**

- A) Cork
- B) Rubber
- C) Steel
- D) Concrete

  Answer: B

15. **Which property indicates the ability of a material to absorb energy up to fracture?**

- A) Toughness

- B) Hardness
- C) Elasticity
- D) Malleability
  Answer: A

16. **The ability of a material to withstand deformation under tensile stress is known as:**

- A) Ductility
- B) Malleability
- C) Toughness
- D) Hardness
  Answer: A

17. **Which modulus is associated with the change in shape at constant volume?**

- A) Young's modulus
- B) Bulk modulus
- C) Shear modulus
- D) Elastic modulus
  Answer: C

18. **A material that exhibits the same mechanical properties in all directions is called:**

- A) Isotropic
- B) Anisotropic
- C) Homogeneous
- D) Heterogeneous
  Answer: A

19. **The stress required to cause a unit strain in a material is defined as:**

- A) Modulus of elasticity
- B) Yield strength
- C) Ultimate strength
- D) Breaking stress
  Answer: A

20. **The maximum stress that a material can withstand without permanent deformation is called:**

- A) Elastic limit
- B) Yield strength
- C) Ultimate strength
- D) Proportional limit
  Answer: A

21. **Which property measures a material's resistance to localized plastic deformation?**

- A) Toughness
- B) Hardness
- C) Ductility
- D) Elasticity
  Answer: B

22. **Which of the following is a unit of strain?**

- A) Newton
- B) Pascal
- C) Meter
- D) It has no units
  Answer: D

23. **Which of the following statements is true about elastic deformation?**

- A) It is permanent
- B) It occurs beyond the yield point
- C) The material returns to its original shape upon load removal
- D) It leads to fracture
  Answer: C

24. **Which of the following statements is true about brittle materials?**

- A) They exhibit significant plastic deformation before fracture.
- B) They have high ductility.
- C) They fracture with little to no plastic deformation.
- D) They can be drawn into wires easily.
  Answer: C

25. **The slope of the linear portion of a stress-strain curve represents:**

- A) Yield strength
- B) Ultimate tensile strength
- C) Young's modulus
- D) Toughness
  Answer: C

26. **In a tensile test, the necking phenomenon occurs:**

- A) Before the yield point
- B) At the elastic limit
- C) After the ultimate tensile strength is reached

- D) At the proportional limit
  Answer: C

27. **Which property is most important for materials used in springs?**

- A) High density
- B) High modulus of elasticity
- C) Low modulus of elasticity
- D) High thermal conductivity
  Answer: B

28. **Which of the following factors does not affect the elastic modulus of a material?**

- A) Temperature
- B) Material composition
- C) Loading rate
- D) Cross-sectional area
  Answer: D

29. **Which test is commonly used to determine the toughness of a material?**

- A) Tensile test
- B) Impact test
- C) Hardness test
- D) Creep test
  Answer: B

30. **Fatigue failure occurs due to:**

- A) Static loading
- B) Sudden impact
- C) Repeated cyclic loading
- D) Creep
  Answer: C

31. **In a stress-strain curve, the area under the curve represents:**

- A) Elastic limit
- B) Modulus of elasticity
- C) Toughness
- D) Ductility
  Answer: C

32. **A material that exhibits the same mechanical properties in all directions is called:**

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- C) Homogeneous
- D) Heterogeneous

  Answer: A

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- A) Elastic limit
- B) Yield strength
- C) Ultimate strength
- D) Proportional limit

  Answer: A

34. **The ratio of volumetric stress to volumetric strain is known as:**

- A) Young's modulus
- B) Shear modulus
- C) Bulk modulus
- D) Modulus of rigidity

  Answer: C

35. **Poisson's ratio is defined as the ratio of:**

- A) Lateral strain to longitudinal strain
- B) Longitudinal strain to lateral strain
- C) Stress to strain
- D) Strain to stress

  Answer: A

36. **Which of the following materials is most likely to have a Poisson's ratio close to 0.5?**

- A) Cork
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- C) Steel
- D) Concrete

  Answer: B

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- B) Bulk modulus
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- D) Elastic modulus
  Answer: C

40. **A material that exhibits the same mechanical properties in all directions is called:**

- A) Isotropic
- B) Anisotropic
- C) Homogeneous
- D) Heterogeneous
  Answer: A

41. **In a 3D isotropic, linear elastic material, the relationship between stress and strain is governed by:**
42. A. Lame’s equations
43. B. Hooke’s Law
44. C. Newton’s Law
45. D. Bernoulli’s equation
46. Answer: B. Hooke’s Law

42.The maximum stress that a material can withstand without permanent deformation is called:

- A) Elastic limit
- B) Yield strength
- C) Ultimate strength
- D) Proportional limit
  Answer: A

43.Which property measures a material's resistance to localized plastic deformation?

- A) Toughness
- B) Hardness
- C) Ductility

- D) Elasticity
  Answer: B

44. The ratio of volumetric stress to volumetric strain is known as:

- A) Young's modulus
- B) Shear modulus
- C) Bulk modulus
- D) Modulus of rigidity
  Answer: C

45. **In a plane stress condition, which of the following stress components are zero?**

- A. σx and σy
- B. σz and τxz, τyz
- C. τxy and τyz
- D. σx and τxy
  Answer: B. σz and τxz, τyz

46. **Generalized Hooke's Law relates:**

- A) Stress and strain tensors
- B) Force and displacement
- C) Stress and temperature
- D) Strain and time
  Answer: A. Stress and strain tensors

47. **For a uniaxial tensile stress σ, the strain in the perpendicular direction is given by:**

- A) σ / E
- B) -ν(σ / E)
- C) ν(σ / E)
- D) -σ / E
  Answer: B. -ν(σ / E)

48 . **The total strain energy in a 3D elastic body is a function of:**

- A) Only normal stresses
- B) Only shear stresses
- C) All components of stress and strain
- D) Displacement only
  Answer: C. All components of stress and strain

49. **The modulus of rigidity (G) is related to Young's modulus (E) and Poisson's ratio (ν) as:**

- A) $G = E / (1 + \nu)$
- B) $G = E(1 + \nu)$
- C) $G = E / [2(1 + \nu)]$
- D) $G = 2E(1 + \nu)$

  Answer: C. $G = E / [2(1 + \nu)]$

50**. The compatibility equations ensure:**

- A) Stress equilibrium
- B) Strain continuity
- C) Thermal expansion
- D) Isotropic behavior

  Answer: B. Strain continuity

Advanced Heat Transfer

1: Thermal conductivity of non-metallic amorphous solids with decrease in temperature:

A. increases
B. decreases
C. remains constant
D. may increase or decrease depending on temperature

2: The thermal diffusivities for solids are generally:

A. less than those for gases
B. less than those for liquids
C. more than those for liquids and gases
D. more or less same as for liquids and gases

3: Thermal conductivity of water in general with rise in temperature:

A. increases
E. decreases
B. remains constant
C. may increase or decrease depending on temperature

4: Thermal diffusivity of a substance is:

A. proportional of thermal conductivity
B. inversely proportional to k
C. proportional to (k)
D. none of the above

5: A non-dimensional number generally associated with natural convection heat transfer is:

A. Grashoff number
B. Nusselt number
C. Prandtl number
D. Reynold number

6: All radiations in a black body are:

A. reflected
B. refracted
C. transmitted
D. absorbed

7: When heat is Transferred by molecular collision, it is referred to as heat transfer by:

A. conduction
B. convection
C. radiation
D. conduction and convection

8: When heat is Transferred by molecular collision, it is referred to as heat transfer by:

A. conduction
B. convection
C. radiation
D. scattering

9: The amount of radiation mainly depends on:

A. nature of body
B. temperature of body

C. type of surface of body
D. all of the above

10: In regenerator type heat exchanger, heat transfer takes place by:

A. direct mixing of hot and cold fluids
B. a complete separation between hot and cold fluids
C. flow of hot and cold fluids alternately over a surface
D. generation of heat again and again

11: If the temperature of a solid surface changes form 27°C to 627°C, then its emissive power changes in the ratio of:

A. 81
B. 6
C. 9
D. 3

12: Unit of thermal conductivity in S.I. units:

A. J/m^2 sec
B. J/m °K sec
C. W/m °K
D. (B) and (C) above

13: The concept of overall coefficient of heat transfer is used in case of heat transfer by:

A. conduction
B. convection
C. radiation
E. conduction and convection

14: The value of Prandtl number for air is about:

A. 0.1
B. 0.3
C. 0.7
D. 1.7

15: Log mean temperature difference in case of counter flow compared to parallel flow will be:

A. same
B. more
C. less
D. depends on other factors

16: The unit of Stefan Boltzmann constant is:

A. watt/cm^2 °K
B. watt/cm^4 °K
C. watt^2/cm °K^4
D. watt/cm^2 °K^4

17: In free convection heat transfer, Nusselt number is function of:

A. Grashoff No. and Reynold No
B. Grashoff No. and Prandtl No
C. Prandtl No. and Reynold No
D. Grashoff No., Prandtl No. and Reynold No:

18: The thermal diffusivities for gases are generally(a) more than those for liquids(b) less than those for liquids(c) more than those for solids(d) dependent on the viscosity:

A. more than those for liquids
B. less than those for liquids
C. more than those for solids
D. dependent on the viscosity

19-Bernoulli's equation cannot be applied when the flow is

(a) rotational
(b) unsteady
(c) turbulent
(d) all of the above

20-Reynolds number signifies the ratio of

(a) gravity forces top viscous forces
(b) inertial forces to viscous forces
(c) inertia forces to gravity forces
(d) buoyant forces to inertia forces

21-Property of fluid that describes its internal resistance is known as:

(a) viscosity (b) friction

(c) resistance (d) internal energy

22-The continuity equation is the result of application of the following law to the flow field

(a) first law of thermodynamics (b) conservation of energy

(c) Newtons second law of motion (d) conservation of mass

23-Which of the following number is applicable in open hydraulic structure such as spillways, where gravitational force is predominant**?**

(a) Reynold's Number (b) Euler's Number

(c) Weber's Number (d) Froude's Number

24- Evaporative cooling systems are ideal for:

a) hot and dry conditions b) hot and humid conditions

c) cold and humid conditions d) moderately hot but humid conditions

25- Heat transfer in liquid and gases takes place by:

a) conduction b) convection

c) comduction and convection d) radiation

26- For a two-stage cascade system working on Carnot cycle and between low and high temperatures of –90o C and 50o C, the optimum cascade temperature at which the COP will be maximum is given by:

a) –20 °C b) –30 °C

c) –67 °C   d) 0 °C

27- Compared to compression systems, absorption systems offer the benefits of:

a) higher COPs   b) lower refrigeration temperatures

c) possibility of using low-grade energy sources   d) all of the above

28- Which of the following is the extensive property of a thermodynamic system?

(a) pressure   (b) volume

c) temperature   (d) density.

29- The amount of heat required to raise the temperature of 1 kg of water through 1 ℃ is called

(a) specific heat at constant volume   (b) specific heat at constant pressure

(c) kilo calorie   (d) none of the above

.

30- The latent heat of evaporation at critical point

(a) less than zero   (b) greater than zero

(c) equal to zero   (d) none of the above.

31- In throttling process

(a) ${h_1}^2 = h_2$ (b) $h_1 = h_2$

(c) $h_1 = h_2 + \frac{h_{fg}}{T_s}$ (d) $h_2 = h_1 + \frac{h_{fg}}{T_s}$

32- Thermal conductivity of glass-wool varies from sample to sample because of variation in

(a) composition   (b) density

(c) porosity   (d) all of the above

33- Second law of thermodynamics defines

(a) heat (b) work

(c) enthalpy (d*)* entropy

34- The Carnot efficiency of a power cycle operate between a hot reservoir at T_1 = 2000 K and reject energy to a cold reservoir at T_2 =400 K is equal:

(a) 0.85 (85%) (b) 0.80 (80%)

(c) 0.76 (76%) (d) 0.30 (30 %)

35- Sensible heat is the heat required to

(a) convert water into steam and super-heated it (b) increase the temperature of water or vapour

(c) change liquid into vapour (d) conditions change steadily with the time

39. The ratio of energy transferred by convection to that by conduction is called

(a) - Stanton number *(b)* - Nusselt number

(c) - Biot number *(d)* - Preclet number

36. Air at 20° C blows over a plate of 50 cm x 75 cm maintained at 250° C. If the convection heat transfer coefficient is 25 W/m^2 °C, the heat transfer rate is

(a) - 215.6 kW *(b)* - 2156 kW

(c) - 2.156 kW *(d)* - 21.56 Kw

37. What is the ratio of the buoyancy force to the viscous force acting on a fluid called.

(a) – Prandtl number (Pr) (b) – Reynolds number (Re)

(c) – Nusselt number (Nu) (d) – Grashof number (Gr)

38. For laminar flow over a flat plate, the average value of a Nusselt number is prescribed by the relation Nu = 0.664 $(Re)^{0.5}$ $(Pr)^{0.33}$:

(a) – Density has to be increased four times (b) – Plate length has to be decreased four times

(c) – Specific heat has to be increased four times (d) – Dynamic viscosity has to be decreased sixteen times

Advance Thermodynamic

1) The degree of disorder of a mixture of two gases

a. is always less than the degrees of disorder of individual gases
b. is always greater than the degrees of disorder of individual gases
c. is always equal to the degrees of disorder of individual gases
d. none of the above

2) The total energy of the universe

a. is always increasing
b. is always decreasing
c. either increases or decreases
d. is always constant

3) Carnot cycle contains two reversible adiabatic process and

a. two reversible isentropic processes

b. two reversible isobaric processes
c. two reversible isochoric processes
d. two reversible isothermal processes

4) **What is the equation for entropy of a system if two parts 1 and 2 having entropies S1 and S2 are considered in equilibrium?**

a. $S = S_1 – S_2$
b. $S = S_1 + S_2$
c. $S = (S_1 + S_2) / 2$
d. $S = \sqrt{}S_1 S_2$

5) **What is the reason behind the fact that the absolute zero entropy value is not attainable?**

a. because absolute zero temperature is not attainable in a finite number of operations
b. because theoretically absolute zero temperature has a negative value of entropy and it is not possible
c. both a. and b.
d. none of the above

6) **The entropy generation**

a. does not depend upon path followed by a system
b. depends upon path followed by a system
c. takes place in reversible process
d. none of the above

7) **How is the entropy of a closed system increased?**

a. by interaction of heat
b. by internal irreversibilities
c. by dissipative effect in which work is dissipated to increase internal energy of the closed system
d. all of the above

8) **When system gains entropy from the surrounding, what will be the effect on the molecules of the system?**

a. molecular disorder increases
b. molecular disorder decreases
c. no change on molecular system
d. none of the above

9) **What is the entropy transfer associated with work?**

a. positive entropy transfer
b. negative entropy transfer
c. no entropy transfer
d. all of the above

10) A body is at a temperature T1 with certain heat capacity and a heat engine is operated between the body and a thermal heat reservoir at temperature (T0). What will be the final temperature of the body when heat engine will stop working?

a. T1
b. T0
c. (T1 + T0) / 2
d. Tf = √T1 T2

11) The ratio of the increase in exergy of the surroundings to the loss of exergy of the system is called

a. effectiveness
b. efficiency
c. entropy
d. work done

12) People use electric energy to heat and light homes. What does it indicate?

a. People are destroying energy
b. People are creating energy
c. People are converting energy from a higher exergy value to a lower exergy value
d. People are converting energy from less exergy value to more exergy value

13) What does the exergy principle state?

a. The exergy of an isolated system can never decrease, but always increases
b. The exergy of an isolated system can never increase, but always decreases
c. The exergy of an isolated system can either increase or decrease
d. Remains constant

14) Which will be a suitable condition of exergy loss and entropy generation for a thermodynamically efficient process?

a. maximum exergy loss with minimum rate of entropy generation
b. minimum exergy loss with maximum rate of entropy generation
c. maximum exergy loss with maximum rate of entropy generation
d. minimum exergy loss with minimum rate of entropy generation

15) How is the Gibbs function (G) represented? Where U represents internal energy T represents temperature S represents entropy?

a. G = U + pV + TS
b. G = U – pV – TS
c. G = U + pV – TS
d. G = U – pV + TS

16) How is the Helmholtz function (A) represented? Where U represents internal energy T represents temperature S represents entropy?

a. A = U + TS
b. A = U - TS
c. A = UT - S
d. A = UT + S

17) Two reversible processes undergone by a closed system between same two end states

a. produce different amounts of work
b. produce the same amount of work if two systems exchange energy between themselves
c. produce the same amount of work if two systems exchange energy with the surroundings
d. none of the above

18) Consider the same heat loss to the surroundings at temperature T_o is occurring from the systems A and B at different temperatures T_1 and T_2, respectively. If T_1 is greater than T_2, what is the exergy loss in both systems?

d. loss of exergy is more in system A than system B
e. loss of exergy is more in system B than system A
f. loss of exergy is same is both systems A and B
g. cannot say

19) Which concept provides a useful measure of the quality of energy?

d. entropy
e. exergy
f. energy
d. none of the above

20) As the temperature difference between the system and the surroundings decreases, the quality of the energy that is being transferred

a. increases

b. decreases
c. remains the same
d. none of the above

21) Which of the following is not a thermodynamic potential?
a. Internal Energy
b. Enthalpy
c. Gibbs Free Energy
d. Entropy

22) The Maxwell relations are derived from which fundamental principle?
a. First law of thermodynamics
b. Second law of thermodynamics
c. Thermodynamic potentials
d. Equation of state

23) The thermodynamic potential most suitable for constant temperature and volume processes is:
a. Gibbs free energy
b. Helmholtz free energy
c. Enthalpy
d. Internal energy

24) The differential form of internal energy is:
a. dU = TdS + PdV
b. dU = TdS − PdV
c. dU = SdT − VdP
d. dU = − PdV + TdS

25) The Maxwell relation from the Helmholtz free energy A(T,V) is:
a. $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

b. $\left(\frac{\partial S}{\partial T}\right)_V = \left(\frac{\partial V}{\partial T}\right)_S$

c. $\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$

d. $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$

26) Enthalpy H is defined as:
a. H = U + PV
b. H = U − PV
c. H = TS + PV
d. H = A + TS

27) The thermodynamic identity for enthalpy H is:

a. dH = TdS + VdP
b. dH = TdS − PdV
c. dH = SdT + VdP
d. dH = TdP + SdV

28) Which Maxwell relation corresponds to the Gibbs free energy G(T,P)?

a. $\left(\frac{\partial V}{\partial T}\right)_P = \left(\frac{\partial S}{\partial P}\right)_T$
b. $\left(\frac{\partial S}{\partial T}\right)_P = \left(\frac{\partial V}{\partial T}\right)_P$
c. $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$
d. $\left(\frac{\partial V}{\partial P}\right)_T = \left(\frac{\partial S}{\partial T}\right)_P$

29) Which of the following variables is held constant in the partial derivative $\left(\frac{\partial U}{\partial S}\right)_V$?

a. Entropy
b. Volume
c. Temperature
d. Pressure

30) Which of the following expresses the total differential of Gibbs free energy G?

a. dG = − SdT + VdP
b. dG = SdT + PdV
c. dG = TdS + VdP
d. dG = TdS − PdV

Advanced Engineering Materials

Advanced Casting Process

1. Which of the following is NOT a classification of metal fabrication techniques?

a) Forming Operations

b) Machining

c) Electroplating

d) Casting

2. Net-shape manufacturing aims to produce parts:

a) Requiring multiple finishing steps

b) Close to final dimensions in one operation

c) With high porosity

d) Using only welding processes

3. Solidification of pure metals occurs:

a) Over a temperature range

b) At a constant temperature

c) Only under vacuum

d) With dendritic growth

4. The mushy zone in alloys is defined by the difference between:

a) Liquidus and solidus temperatures

b) Pouring and freezing temperatures

c) Mold and metal temperatures

d) Dendrite arm spacing

5. Chvorinov's rule states that solidification time is proportional to:

a) $(\text{Volume}/\text{Surface Area})^2$

b) $(\text{Surface Area}/\text{Volume})^2$

c) Cooling rate × Volume

d) Thermal conductivity × Density

6. A tapered sprue is designed to prevent:

a) Turbulence

b) Aspiration

c) Shrinkage

d) Hot tearing

7. Reynolds number (Re) in fluid flow indicates:

a) Ratio of inertial to viscous forces

b) Thermal gradient

c) Mold permeability

d) Shrinkage rate

8. Porosity in castings caused by trapped gases typically has:

a) Rough, angular walls

b) Smooth, spherical cavities

c) Columnar grains

d) Surface cracks

9. Hot tearing occurs due to:

a) Rapid cooling

b) Constraints during shrinkage

c) Low pouring temperature

d) Excessive fluidity

10. Which material expands during solidification?

a) Aluminum

b) Gray cast iron

c) Copper

d) Carbon steel

11. The function of a riser is to:

a) Trap impurities

b) Supply molten metal to compensate for shrinkage

c) Increase mold permeability

d) Reduce turbulence

12. Fluidity is inversely proportional to:

a) Mold conductivity

b) Freezing range

c) Superheat

d) Surface tension

13. In freeze casting, the carrier fluid is removed by:

a) Sublimation under vacuum

b) High-pressure injection

c) Centrifugal force

d) Chemical etching

14. Columnar grains grow preferentially in the direction:

a) Opposite to heat transfer

b) Parallel to mold walls

c) Randomly distributed

d) Along the liquidus line

15. Microsegregation refers to:

a) Composition differences across a casting

b) Variations within dendrite arms

c) Gravity-driven separation

d) Mold material impurities

16. Thixotropic behavior in semisolid metals means viscosity:

a) Increases with agitation

b) Decreases with agitation

c) Is unaffected by temperature

d) Depends on mold material

17. A chill is used to:

a) Increase porosity

b) Accelerate solidification in specific regions

c) Reduce fluidity

d) Trap slag

18. Bernoulli's equation includes terms for:

a) Pressure, velocity, and elevation

b) Density, viscosity, and temperature

c) Surface tension, turbulence, and shrinkage

d) Grain size, dendrite spacing, and cooling rate

19. The Reynolds number formula is:

a) $Re = (vD\rho)/\eta$

b) $Re = (v\eta)/D\rho$

c) $Re = (\rho D)/v\eta$

d) $Re = (\eta\rho)/vD$

20. For a cube and sphere of equal volume, which solidifies faster?

a) Cube

b) Sphere

c) Both solidify simultaneously

d) Depends on mold material

21. If the sprue height doubles, the exit velocity increases by a factor of:

a) $\sqrt{2}$

b) 2

c) 4

d) 8

22. Cold shuts are caused by:

a) Premature solidification of metal streams

b) Excessive superheat

c) High fluidity

d) Low mold permeability

23. Dross refers to:

a) Surface oxides and impurities

b) Internal shrinkage cavities

c) Columnar grains

d) Mold material residues

24. Incomplete casting due to metal loss from the mold is called:

a) Misrun

b) Runout

c) Cold shut

d) Blowhole

25. A defect categorized as a "metallic projection" is:

a) Flash

b) Porosity

c) Hot tear

d) Inclusion

26. Filters in gating systems are used to remove:

a) Turbulence

b) Slag and dross

c) Dendrites

d) Chills

27. Which metal has the highest melting point?

a) Aluminum

b) Tungsten

c) Copper

d) Lead

28. Surface tension in molten metal is increased by:

a) Oxide films

b) Superheat

c) Inoculants

d) Chills

29. The thermal conductivity of mold materials affects:

a) Fluidity

b) Grain size

c) Both a and b

d) Neither a nor b

30. Which alloy solidifies with a lamellar structure?

a) Eutectic

b) Solid-solution

c) Pure metal

d) Hypereutectic

31. Directional solidification is promoted by:

a) Uniform mold thickness

b) External chills

c) High superheat

d) Turbulent flow

32. In investment casting, the pattern is made of:

a) Sand

b) Wax

c) Ceramic

d) Foam

33. Lost-foam casting uses a pattern made of:

a) Polystyrene

b) Metal

c) Plaster

d) Graphite

34. Centrifugal casting is suitable for:

a) Thin-walled cylinders

b) Complex internal cavities

c) Microscale components

d) Low-melting-point alloys

35. Heterogeneous nucleation is induced by:

a) Inoculants

b) High cooling rates

c) Pure metals

d) Turbulence

36. Macrosegregation refers to composition variations:

a) Within dendrite arms

b) Across the entire casting

c) At grain boundaries

d) Due to mold reactions

37. Semisolid metal forming exploits:

a) Thixotropic behavior

b) High fluidity

c) Rapid solidification

d) Low viscosity

38. Which casting process uses evaporative patterns?

a) Sand casting

b) Lost-foam casting

c) Die casting

d) Investment casting

39. A "choke" in a gating system reduces:

a) Fluidity

b) Aspiration

c) Shrinkage

d) Porosity

40. Inoculants in casting promote:

a) Fine-grain structure

b) Columnar growth

c) Turbulence

d) Surface oxidation