PART III

05 - MECHANICAL ENGINEERING

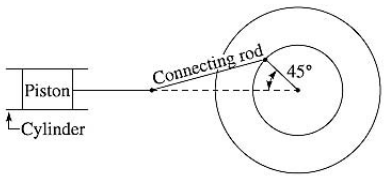
(Answer ALL questions)

41. A bullet is fired upwards at an angle of 30° to the horizontal from a point P on a hill, and it strikes a target which is 80 m lower than P. The initial velocity of the bullet is 100 m/s. Calculate the maximum height to which the bullet will rise above the horizontal. Assume $g = 9.81\ m/s^2$.
    a. 150.8 m
    b. 100.5 m
    c. 140.2 m
    d. 127.6 m

42. The condition for a screw jack to be self-locking is that
    a. Its efficiency should be the maximum possible
    b. Its efficiency should be the minimum possible
    c. It should not unwind to lower the load if left to itself
    d. Its efficiency should be more than 50%

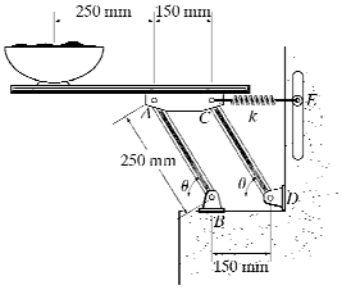
43. The first moment of area of a semicircular area about its diameter 'd' is given by
    a. $d^3/36$
    b. $d^3/12$
    c. $d^3/24$
    d. $d^3/6$

44. A reciprocating pump driven by a driving wheel is shown in the below figure. If crank is 80 mm long and connecting rod 200 mm, determine the velocity of the piston in the position shown. The driving wheel rotates at 2000 rpm in anticlockwise direction.



    a. 15.34 m/s
    b. 30.61 m/s
    c. 31.45 m/s
    d. 72.82 m/s

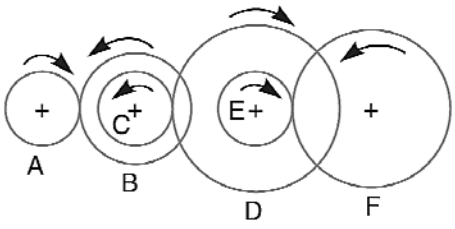
45. A 5-kg uniform serving table is supported on each side by two pairs of identical links, AB and CD, and springs CE as shown in the below figure. If the bowl has a mass of 1 kg and is in equilibrium when θ = 45°, determine the stiffness k of each spring. The springs are upstretched when θ= 90°. Neglect the mass of the links.



    a. 88 N/m
    b. 166 N/m
    c. 194 N/m
    d. 138 N/m

46. Calculate the power transmitted through belt drive (in kW) if tension on tight and slack sides are 200 N and 50 N, respectively. The linear velocity of belt speed is 10 m/s.
    a. 2.5 kW
    b. 1 kW
    c. 2 kW
    d. 1.5 kW

47. The gearing of a machine tool is shown in the below figure. The motor shaft is connected to gear A and rotates at 975 rpm. The gear wheels B, C, D and E are fixed to parallel shafts rotating together. The final gear F is fixed on the output shaft. What is the speed of gear F? The number of teeth on each gear are as follows: A=20; B=50; C=25; D=75; E=26 and F=65.

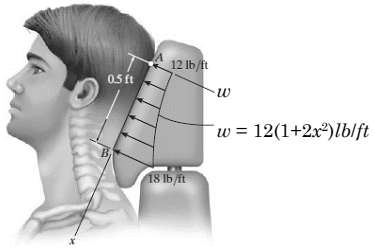


    a. 78
    b. 104
    c. 52
    d. 98

48. When the rotor rotates in the anticlockwise direction and viewed from the stern while the ship is steering to the left, then the effect of reactive gyroscopic couple will be

a. To lower the bow and lower the stern
b. To raise the bow and lower the stern
c. To raise the bow and raise the stern
d. To lower the bow and raise the stern

49. Currently eighty-five percent of all neck injuries are caused by rear-end car collisions. To alleviate this problem, an automobile seat restraint has been developed that provides additional pressure contact with the cranium. During dynamic tests the distribution of load on the cranium has been plotted and shown to be parabolic. Determine the equivalent resultant force and its location, measured from point A.



a. $F_R = 7\,lb$ and $\bar{x} = 0.268\,ft$
b. $F_R = 5\,lb$ and $\bar{x} = 0.223\,ft$
c. $F_R = 12\,lb$ and $\bar{x} = 0.718\,ft$
d. $F_R = 4\,lb$ and $\bar{x} = 0.482\,ft$

50. For a flywheel, if I = mass moment of inertia of flywheel, w_{av} = average rotational speed, K_s= coefficient of fluctuation of speed given by $(w_{max} - w_{min})/w_{av}$. Then, find the maximum fluctuation of energy during a cycle.

a. $I\,K_s(w^2_{max} - w^2_{min})$
b. $0.5 \mid w_{av}(w_{max} - w_{min}).KS$
c. $0.5 \mid K_s w^2_{av}$
d. $\mid K_s w^2_{av}$

51. A beam with a span of 4.5 meter carries a point load of 30 kN at 3 meter from the left support. If for the section, $I_{xx} = 54.97 \times 10^{-6} m^4$ and E=200 GN/m², then the deflection under the load is

a. 7.11 mm
b. 4.09 mm
c. 3.27 mm
d. 5.92 mm

52. A wire of length L and radius r is rigidly clamped from one end and other end is pulled by force F. It is found that wire elongates by 5 cm. Another wire of same material but 4L length and 4r radius is pulled by 4F forces under identical conditions, then what will be the final length of wire?

a. 16 cm
b. 1/16 cm
c. 5 cm
d. 4 cm

53. A slender pin ended aluminium column 1.8 m long and of circular cross-section is to have an outside diameter of 50 mm. Calculate the necessary internal diameter to prevent failure by buckling if the actual load applied is 13.6 kN and the critical load applied is twice the actual load. Take E for aluminium as E=70 GN/m².

a. 39.4 mm
b. 47.2 mm
c. 43.7 mm
d. 42.8 mm

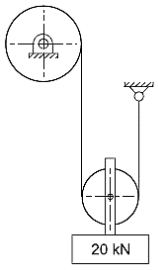
54. A boiler drum consists of a cylindrical portion 4 m long, 1.5 m in diameter and 2.25 cm thick. It is closed by hemispherical ends. In a hydraulic test to 6 MN/m², how many liters of additional water will be pumped in after initial filling at atmospheric pressure? The hoop strain at the junction of the cylinder and hemisphere may be assumed to be the same for both. Consider, E=200 GN/m²; for water, K= 2.13 GN/m² and 1/m=0.3.

a. 45.3
b. 42.8
c. 52.7
d. 61.9

55. A hollow rectangular column has external and internal dimensions as $2.4\,m \times 1.8\,m$ and $1.2\,m \times 1.2\,m$ respectively. Calculate the safe load that can be placed at an eccentricity of 0.5 m on a plane bisecting the longer side, if the maximum compressive stress is not to exceed 5 MN/m².

a. 72 kN
b. 270 kN
c. 720 kN
d. 27 kN

56. $A6\times19$ wire rope with fiber core and tensile designation of 1570 is used to raise the load of 20 kN as shown in the below figure. The nominal diameter of the wire rope is 12 mm, and the sheave has 500 mm pitch diameter. Determine the expected life of the rope in years assuming 500 bends per week.



a. 92.61
b. 19.12
c. 26.91
d. 12.69

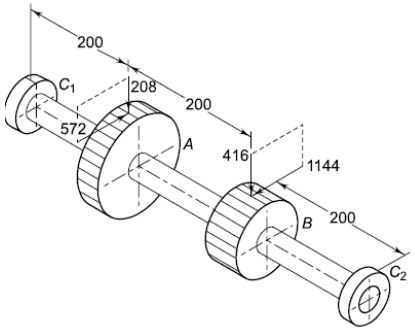
57. A riveting machine is driven by a constant torque 3 kW motor. The moving parts including the flywheel are equivalent to 150 kg at 0.6 m radius. One riveting operation takes 1 second and absorbs 10000 N-m of energy. The speed of the flywheel is 300 r.p.m. before riveting. Find the speed immediately after riveting. How many rivets can be closed per minute?

a. 260 rpm and 18
b. 290 rpm and 36
c. 360 rpm and 9
d. 390 rpm and 200

58. The following are the selection characteristics considered while choosing a material for brake lining. Identify the incorrect characteristic.

a. It should have low wear rate
b. It should have low coefficient of friction with maximum fading
c. It should have high heat dissipation capacity
d. It should not be affected by moisture and oil

59. An intermediate shaft of a gearbox, supporting two spur gears A and B and mounted between two bearings C_1 and C_2, is shown in the below figure. The pitch circle diameters of gears A and B are 500 and 250 mm respectively. The shaft is made of alloy steel 20MnCr5. *(S_{ut} = 620 and S_{yt} = 480 N/mm^2).* The factors k_b and k_t of the ASME code are 2 and 1.5 respectively. The gears are keyed to the shaft. Determine the shaft diameter using the ASME code.



a. 44.52 mm
b. 59.36 mm
c. 27.15 mm
d. 38.87 mm

60. The maximum pull in the tie rods of a turnbuckle used in the roof truss is 4.5kN. The tie rods are made of steel 40C8 $(S_{yt} = 380\,N/mm^2)$ and the factor of safety is 5. Determine the nominal diameter of the threads on the tie rod on the basis of maximum principal stress theory. Assume $d_c = 0.8d$.

a. 21.91 mm
b. 11.92 mm
c. 12.91 mm
d. 19.21 mm

61. Which of the following is not a principal classification model representing the 3D geometric modelling?

a. Line
b. Surface
c. Primitives
d. Volume

62. For maintaining records, _____ cards contain information on the (a) type of part, (b) location where the card was issued, (c) part number, and (d) number of items in the container.

a. Production and conveyance
b. Routing
c. Scheduling
d. Follow-Up

63. Calculate the matrix product $C = AB$, where

$$A = \begin{bmatrix} 5 & 3 & 1 \\ 4 & 6 & 2 \\ 10 & 3 & 4 \end{bmatrix}; \; B = \begin{bmatrix} 1 & 5 \\ 2 & 4 \\ 3 & 2 \end{bmatrix}$$

a. $\begin{bmatrix} 14 & 38 \\ 22 & 48 \\ 28 & 70 \end{bmatrix}$

b. $\begin{bmatrix} 14 & 39 \\ 22 & 48 \\ 29 & 70 \end{bmatrix}$

c. $\begin{bmatrix} 14 & 39 \\ 22 & 48 \\ 28 & 70 \end{bmatrix}$

d. $\begin{bmatrix} 14 & 39 \\ 22 & 49 \\ 28 & 70 \end{bmatrix}$

64. According to ———————— equation "for most metals, yield strength depends on average grain diameter"

a. Young
b. Bragg's law
c. Nernst
d. Hall–Petch

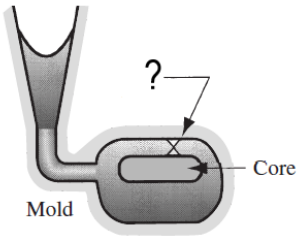
65. Which of the statements is not true for Bainite, which is a micro constituent in Iron–Carbon Alloys?

a. The phases present in Bainite are α-Ferrite + Fe_3C
b. Hardness and strength is less than fine Pearlite
c. Hardness is less than Martensite
d. Ductility is greater than Martensite

66. Having a eutectoid composition ———————— is a microstructural product of an iron–carbon alloy consisting of alternating layers of ferrite and cementite.

a. Austenite
b. Delta-ferrite
c. Martensite
d. Pearlite

67. Identify the correct type of defect for casting shown below:



a. Cold shut
b. Cold shots
c. Hot tearing
d. Shrinkage cavity

68. Cracks appear in weld and base metal when the localized stresses exceed the ———————— strength of a metal.

a. Shear
b. Compressive
c. Ultimate
d. Yield

69. In a machining operation that approximates orthogonal cutting, the cutting tool has a rake angle of 10°. The chip thickness before the cut $t_o = 0.50\,mm$ and the chip thickness after the cut $t_c = 1.125\,mm$. The shear plane angle ϕ is ————————. Assuming $\sin 10^\circ = 0.173$ and $\cos 10^\circ = 0.984$.

a. 0.008°
b. 25.4°
c. 50.4°
d. 20.5°

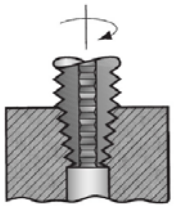
70. The term "bulk" in bulk deformation processes describes the work parts that have ———————— ratio.

a. Low area-to-volume
b. High area-to-volume
c. Low modulus-to-strength
d. High modulus-to-strength

71. Identify the operation which cannot be performed using a conventional lathe.

a. Contour turning
b. Chamfering
c. Planning
d. Facing

72. Identify the operation related to drilling which is illustrated in Figure below.



a. Reaming
b. Tapping
c. Counter boring
d. Center drilling

73. The application for which a point to point numerical control system can be employed is a
a. Hobbling machine
b. Cutting machine
c. Lathe machine
d. Punching Machine

74. In laser beam welding, ———————— are associated with the evolution of vapor from the surface of the material to produce a needle-like, vapor-filled cavity or keyhole in the work piece through which the beam can penetrate.
a. Magnetic forces
b. Tensile forces
c. Compressive forces
d. Recoil forces

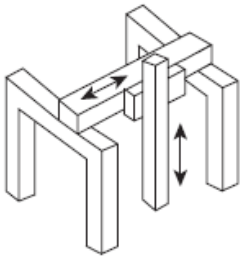
75. Which of the following is an incorrect operation in relation to the finishing processes employed for gear teeth?
a. Gear trimming
b. Gear shaving
c. Gear grinding
d. Burnishing

76. Which of the following options does not belong to a special purpose lathe?
a. Wheel lathe
b. Gap bed lathe
c. Crank shaft lathe
d. Rear edge lathe

77. What structure is formed in the heat affected zone of a medium carbon steel weld due to rapid cooling?
a. Pearlite
b. Ferrite
c. Martensite
d. Austenite

78. Inside size of slots or holes can be measured by
a. Tachometer
b. Hammer gauge
c. Telescopic gauge
d. Telegraphic gauge

79. Which is the correct type of configuration of a CMM from the figure presented below?



a. Column type
b. Gantry type
c. Moving bridge
d. Moving lever cantilever arm

80. Which of the following provides a quick-fix means of conducting an initial investigation before attempting a major investigation of surface quality?
a. Tomlinson surface meter
b. Taylor–Hobson talysurf
c. Light interference microscope
d. Profilometer

81. The following options represent the work done (W) and heat transfer (Q) relations for the various thermodynamic process. Identify the INCORRECT option. [Consider c_v, c_p - Specific heats at constant volume and constant pressure respectively, p- pressure, v, v_1, v_2 – Specific volumes of working fluid, T_1, T_2 – Temperature at starting and end of the process.)
a. Isochoric process
$\rightarrow W = 0, Q = c_v(T_2 - T_1)$
b. Isobaric process
$\rightarrow W = p(v_2 - v_1), Q = c_p(T_2 - T_1)$
c. Throttling process $\rightarrow W = Q = 0$
d. Isothermal Process
$W = 0, Q = p_1 v_1 \log_e\left(\frac{T_1}{T_2}\right)$

82. All of the following options describe the availability and unavailable energy of a system EXCEPT:

a. Availability depends on the system and the surroundings

b. Availability is defined as the maximum work output obtainable from a certain heat input in a cyclic heat engine

c. Unavailable energy is defined as minimum energy that has to be rejected to the sink by the second law

d. When heat is transferred through the finite temperature difference, the available energy transferred remains constant

83. Air enters the compressor at 100 kPa and 25°C having the volume of 1.8 m^3/kg and compressed to 5 bar isothermally. The change in internal energy during the process is

a. 0 kJ

b. 37 kJ

c. 1 kJ

d. 73 kJ

84. $\left(\frac{\partial P}{\partial V}\right)_T\left(\frac{\partial V}{\partial T}\right)_P\left(\frac{\partial T}{\partial P}\right)_V$ is equal to the value of

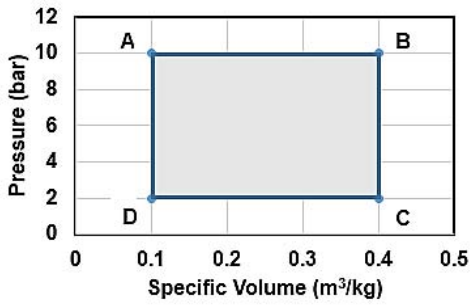
a. Zero

b. 1

c. –1

d. Infinity

85. Consider the indicator diagram for the heat engine as shown in the following figure. If the heat rejected by the engine to a heat sink is 1250 kJ/kg, the thermal efficiency (by considering one decimal place) of the engine is:



a. 8 %

b. 16 %

c. 24 %

d. 32 %

86. For a balanced counter flow heat exchanger where $\dot{m}_h Cp_h = \dot{m}_c Cp_c$, the logarithmic mean temperature difference (LMTD) and temperature profile is:

a. ΔT at any section = Constant, parallel, linear

b. 0, parallel, linear

c. ΔT at any section = Constant, parallel, non-linear

d. 0, parallel, non-linear

87. A slab of 250 mm thick is made up of material 'X' and its thermal conductivity is $500\frac{W}{m-K}$. The one of the surface is kept at $100^\circ C$ and another surface is maintained at $25^\circ C$. The net heat flux across the surface is

a. 150 kW/m^2

b. 250 kW/m^2

c. 100 kW/m^2

d. 200 kW/m^2

88. The characteristics of Planks black body radiation distribution is given in the options. Which of the following is NOT a characteristic of Planks black body radiation distribution?

a. As temperature increases, peak of the curve shift towards higher wavelength

b. Spectral emissive power varies continuously with change in wavelength

c. At a given wavelength, as temperature increases, emissive power also increases

d. Total emissive power is proportional to T^4

89. If Stanton number is 0.5, Reynolds number is 39 and Nusselt number is 390, then the Prandtl number is

a. 1

b. 10

c. 2

d. 20

90. Consider the following statements regarding Mass Transfer. Identify the INCORRECT statement.

a. Mass transfer refers to mass in transit due to a species concentration gradient in a mixture

b. Only one species is sufficient for mass transfer to occur

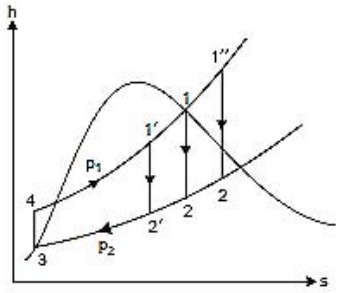
c. The species concentration gradient is the driving potential for mass transfer

d. Mass transfer by diffusion is analogous to heat transfer by conduction

91. For the same maximum pressure and same heat input in the air standard cycles, which of the following option is CORRECT?
   a. Diesel cycle is less efficient than Otto cycle
   b. Otto cycle is less efficient than Diesel cycle
   c. Otto and Diesel cycles have equal efficiency
   d. Carnot cycle is less efficient than Otto cycle

92. In a Vapour Compression Refrigeration System (VCRS), if throttle valve is replaced with expansion cylinder, the COP will
   a. Increase
   b. Decrease
   c. Remain Same
   d. Not be predictable unless refrigerant used is known

93. Consider the h-s diagram for the Rankine Cycle as shown in Figure. According to the h-s diagram, which of the following steady flow devices is responsible for process 3-4?



   a. Boiler
   b. Container
   c. Condenser
   d. Feed pump

94. A heat pump operates on Carnot cycle pumps heat from a reservoir at 27 °C to 327 °C. The Coefficient of performance is
   a. 1.5
   b. 0.5
   c. 2
   d. 1

95. If SH, LH represents Sensible Heat and Latent Heat respectively, then identify the CORRECT relation for Sensible Heat Factor (SHF) from the given options.
   a. $SHF = \frac{LH}{(SH + LH)}$
   b. $SHF = \frac{LH}{(SH - LH)}$
   c. $SHF = \frac{SH}{(SH + LH)}$
   d. $SHF = \frac{SH}{(SH - LH)}$

96. A pool is filled with water and the pool has a maximum depth of 100 m. If the atmospheric pressure 101 kPa, the absolute pressure at 100 mm depth of the pool is
   a. 900 kPa
   b. 1082 kPa
   c. 678 kPa
   d. 881 kPa

97. If k is the average height of irregularities and δ is the thickness of laminar sub layer, then the boundary is known to be hydro dynamically rough when
   a. $(k/\delta) > 6$
   b. $2.5 < (k/\delta) < 6$
   c. $(k/\delta) = 0$
   d. $(k/\mathrm{R}) < 0$

98. In a hydraulic system, the point of intersection of the line of action of the resultant hydrostatic force and the corresponding surface is known as
   a. Centre of pressure
   b. Centre of locust
   c. Centre of velocity
   d. Centre of momentum

99. If V is velocity of fluid flow, V_1 and V_2 are velocity at inlet and outlet of the pipe, respectively and k is the value of the coefficient depending on the fittings, then which of the following options has the correct match of case and loss of head?

	Case		Loss of head, h
(i)	Sudden enlargement	(a)	$\frac{V_2^2}{2g}$
(ii)	Entrance of the pipe	(b)	$\frac{(V_1 - V_2)^2}{2g}$
(iii)	Exit of the pipe	(c)	$\frac{0.5V^2}{2g}$
(iv)	Pipe fittings	(d)	$\frac{kV^2}{2g}$

   a. (i) – (b), (ii) – (c), (iii) – (d), (iv) – (a)
   b. (i) – (c) , (ii) – (d) , (iii) – (b) , (iv) – (a)
   c. (i) – (a) , (ii) – (c) , (iii) – (b) , (iv) – (d)
   d. (i) – (b), (ii) – (c) , (iii) – (a) , (iv) – (d)

100. A fluid jet discharges from 100 mm diameter nozzle and vena contracta formed has a diameter of 90 mm. If the coefficient of velocity is 0.95, then the coefficient of discharge of the Nozzle is
   a. 0.77
   b. 0.81
   c. 0.90
   d. 0.86