



# Punjab Technical University

Maximum Marks: 90

Time: 90Mins.

## Entrance Test for Enrollment in Ph.D Programme

### Important Instructions

- Fill all the information in various columns, in Capital letters, with blue/black point pen for attempting the questions
- Use of calculators is not allowed.
- Make attempt by writing the answer in capital Letters in the box against each question number.
- All questions are compulsory. Each Question has only one right answer. No Negative marking for wrong answers.
- Questions attempted with two or more options/answers will not be evaluated.

Stream: .....Engineering .....

Discipline .....Mechanical Engineering.....

Name .....

Fathers Name .....

Roll Number Date: 13-07-2014

Signature of Candidate: .....

Signature of Invigilator .....

1. The Young's modulus of elasticity of a material is 2.5 times its modulus of rigidity.  
The Posson's ratio for the material will be:-

- (a) 0.25      (b) 0.33      (c) 0.50      (d) 0.75

2. Consider the following statements:

In a cantilever subjected to a concentrated load at the free end

- 1) The bending stress is maximum at the free end
- 2) The maximum shear stress is constant along the length of the beam
- 3) The slope of the elastic curve is zero at the fixed end

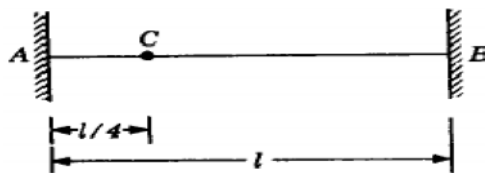
Which of these statements are correct?

(a) 1, 2 and 3 (b) 2 and 3 (c) 1 and 3 (d) 1 and 2

3. Angle of twist of a shaft of diameter 'd' is inversely proportional to

(a) d (b)  $d^2$  (c)  $d^3$  (d)  $d^4$

4. A round shaft of diameter 'd' and length 'l' fixed at both ends 'A' and 'B' is subjected to a twisting moment 'T' at 'C', at a distance of  $l/4$  from A (see figure).



Then the ratio of moment or torque will be

(a) equal (b) in the ratio 1:3 (c) in the ratio 3 :1 (d) indeterminate

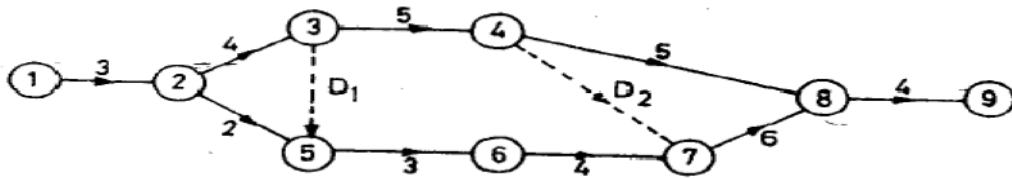
5. From a tension test, the yield strength of steel is found to be 200 MPa. Using a factor of safety of 2 and applying maximum principal stress theory of failure, the permissible stress in the steel shaft subjected to torque will be

(a) 50MPa (b) 57.7MPa (c) 86.6.MPa (d) 100 MPa

6. For a product, the forecast and the actual sales for December 2002 were 25 and 20 respectively. If the exponential smoothing constant ( $\alpha$ ) is taken as 0.2, then forecast sales for January 2003 would be

(a) 21 (b) 23 (c) 24 (d) 27

7. In the network shown below



The critical path is along

- (a) 1-2-3-4-8-9 (b) 1-2-3-5-6-7-8-9 (c) 1-2-3-4-7-8-9 (d) 1-2-5-6-7-8-9

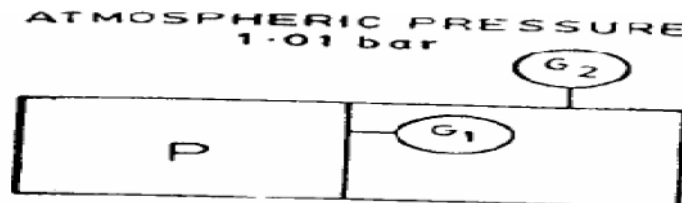
8. The standard time of an operation while conducting a time study is

- (a) mean observed time + allowances  
 (b) normal time + allowances  
 (c) mean observed time x rating factor + allowances  
 (d) normal time x rating factor + allowances

9. For a Newtonian fluid

- (a) Shear stress is proportional to shear strain  
 (b) Rate of shear stress is proportional to shear strain  
 (c) Shear stress is proportional to rate of shear strain  
 (d) Rate of shear stress is proportional to rate of shear strain

10. The pressure gauges G1 and G2 installed on the system show pressures of PG1 = 5.00bar and PG2 = 1.00 bar.



The value of unknown pressure P is? (Atmospheric pressure 1.01 bars)

- (a) 1.01 bar (b) 2.01 bar (c) 5.00 bar (d) 7.01 bar

11. A metallic piece weighs 80 N in air and 60 N in water. The relative density of the metallic piece is will be

- (a) 8 (b) 6 (c) 4 (d) 2

12. When the speed of a centrifugal pump is doubled, the power required to drive the pump will

- (a) increase 8 times      (b) increase 4 times  
(c) double                      (d) remain the same

13. An aeroplane is cruising at a speed of 800 kmph at altitude, where the air temperature is 0 °C. The flight Mach number at this speed could be

- (a) 1.5 (b) 0.254 (c) 0.67 (d) 2.04

14. In a Pelton wheel, the bucket peripheral speed is 10 m/s, the water jet velocity is 25m/s and volumetric flow rate of the jet is 0.1m<sup>3</sup>/s. If the jet deflection angle is 120° and the flow is ideal, the power developed is

- (a) 7.5kW    (b) 15.0 kW    (c) 22.5kW    (d) 37.5kW

15. Which one of the following statements is correct? While using boundary layer equations, Bernoulli's equation

- (a) can be used anywhere  
(b) can be used only outside the boundary layer  
(c) can be used only inside the boundary layer  
(d) cannot be used either inside or outside the boundary layer

16. The primary purpose of a sprue in a casting mould is to

- (a) feed the casting at a rate consistent with the rate of solidification  
(b) act as a reservoir for molten metal  
(c) feed molten metal from the pouring basin to the gate  
(d) help feed the casting until all solidification takes place

17. A spherical drop of molten metal of radius 2 mm was found to solidify in 10 seconds. A similar drop of radius 4 mm would solidify in

- (a) 14.14 seconds    (b) 20 seconds    (c) 28.30 seconds    (d) 40 seconds

18. Which of the following is a single point cutting tool?

- (a) Hacksaw blade    (b) Milling cutter    (c) Grinding wheel    (d) Parting tool

19. In ASA System, if the tool nomenclature is 8-6-5-5-10-15-2-mm, then the side rake angle will be

(a)  $5^\circ$  (b)  $6^\circ$  (c)  $8^\circ$  (d)  $10^\circ$

20. In a single-point turning operation of steel with a cemented carbide tool, Taylor's tool life exponent is 0.25. If the cutting speed is halved, the tool life will increase by

(a) two times (b) four times (c) eight times (d) sixteen times

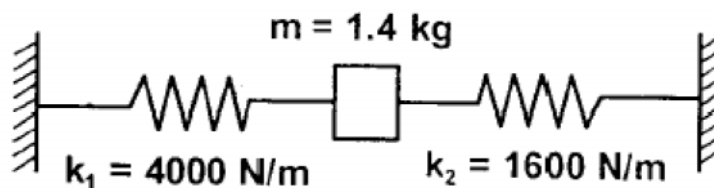
21. The amount of energy absorbed by a flywheel is determined from the

(a) torque-crank angle diagram (b) acceleration-crank angle diagram  
(c) speed-space diagram (d) speed-energy diagram

22. A mass  $m$  attached to a light spring oscillates with a period of 2 sec. If the mass is increased by 2 kg, the period increases by 1 sec. The value of  $m$  is

(a) 1 kg (b) 1.6 kg (c) 2 kg (d) 2.4 kg

23. The natural frequency of the spring mass system shown in the figure is closest to



(a) 8 Hz (b) 10 Hz (c) 12 Hz (d) 14 Hz

24. At what value of the damping factor a motion is aperiodic?

(a) 1.0 or above (b) 0.5 (c) 0.3 (d) 0.866

25. In a slider-crank mechanism, the velocity of piston becomes maximum when

(a) Crank and connecting rod are in line with each other [IES-2003]  
(b) Crank is perpendicular to the line of stroke of the piston  
(c) Crank and connecting rod are mutually perpendicular  
(d) Crank is  $120^\circ$  with the line of stroke

26. The specific heats of an ideal gas depend on its

(a) temperature      (b) pressure      (c) volume      (d) molecular weight and structure

27. A 100 W electric bulb was switched on in a 2.5 m x 3 m x 3 m size thermally insulated room having a temperature of 20°C. The room temperature at the end of 24 hours will be

(a) 321°C      (b) 341°C      (c) 450°C      (d) 470°C

28. A steel billet of 2000 kg mass is to be cooled from 1250 K to 450 K. The heat released during this process is to be used as a source of energy. The ambient temperature is 303 K and specific heat of steel is 0.5 kJ/kg K. The available energy of this billet is

(a) 490.44 MJ      (b) 30.95 MJ      (c) 10.35 MJ      (d) 0.10 MJ

29. A dynamometer is a device

(a) similar to alternator      (b) to measure force  
(c) wear of the cutting tool      (d) similar to dynamo

30. A system undergoes a state change from 1 to 2. According the second law of thermodynamics for the process to be feasible, the entropy change,  $S_2 - S_1$  of the system

(a) is positive or zero      (b) is negative or zero  
(c) is zero      (d) can be positive, negative or zero

31. The determinant of a singular matrix is

(a) Unity      (b) -ve      (c) zero      (d) Zero to Unity

32. Starting from  $X_0 = 1$ , one step of Newton- Raphson method in solving the equation  $X^3 + 3X - 7 = 0$  gives the next value ( $x_1$ ) as

(a)  $x_1 = 0.5$       (b)  $x_1 = 1.406$       (c)  $x_1 = 1.5$       (d)  $x_1 = 2$

33. The order of error Simpson's rule for numerical integration with a step size  $h$  is

(a)  $h$       (b)  $h^2$       (c)  $h^3$       (d)  $h^4$

34. A pair of dices are thrown twice then what is the probability of getting 7 point exactly once

- (a)  $5/18$       (b)  $11/36$       (c)  $1/4$       (d)  $1/3$

35. For what value of x will the given matrix become Singular

$$\begin{matrix} 8 & x & 0 \\ 4 & 0 & 2 \\ 12 & 6 & 0 \end{matrix}$$

- (a) 4    (b) 6    (c) 8    (d) 12

36. A 60 mm long and 6 mm thick fillet weld carries a steady load of 15 kN along the weld. The shear strength of the weld material is equal to 200 MPa. The factor of safety is

- (a) 2.4    (b) 3.4    (c) 4.8    (d) 6.8

37. A threaded nut of M16, ISO metric type, having 2 mm pitch with a pitch diameter of 14.701 mm is to be checked for its pitch diameter using two or three numbers of balls or rollers of the following sizes

- (a) Rollers of 2 mm  $\phi$     (b) Rollers of 1.155 mm  $\phi$     (c) Balls of 2 mm  $\phi$     (d) Balls of 1.155 mm  $\phi$

38. Assertion (A): A cotter joint is used to rigidly connect two coaxial rods carrying tensile load.

Reason (R): Taper in the cotter is provided to facilitate its removal when it fails due to shear.

- (a) Both A and R are true and R is the correct explanation of A  
(b) Both A and R are true but R is NOT the correct explanation of A  
(c) A is true but R is false  
(d) A is false but R is true

39. A clutch has outer and inner diameters 100 mm and 40 mm respectively. Assuming a uniform pressure of 2 MPa and coefficient of friction of liner material 0.4, the torque carrying capacity of the clutch is

- (a) 148 Nm    (b) 196 Nm    (c) 372 Nm    (d) 490 Nm

40. A disk clutch is required to transmit 5 kW at 2000 rpm. The disk has a friction lining with coefficient of friction equal to 0.25. Bore radius of friction lining is equal to 25 mm. Assume uniform contact pressure of 1 MPa. The value of outside radius of the friction lining is

- (a) 39.4 mm (b) 49.5 mm (c) 97.9 mm (d) 142.9 mm

41. In a Rankine cycle, regeneration results in higher efficiency because

- (a) Pressure inside the boiler increases  
(b) Heat is added before steam enters the low pressure turbine  
(c) Average temperature of heat addition in the boiler increases  
(d) Total work delivered by the turbine increases

42. Consider an actual regenerative Rankine cycle with one open feed water heater. For each kg steam entering the turbine, If  $m$  kg steam with a specific enthalpy of  $h_1$  is bled from the turbine, and the specific enthalpy of liquid water entering the heater is  $h_2$ , then  $h_3$  specific enthalpy of saturated liquid leaving the heater is equal to

- (a)  $m h_1 - (h_2 - h_1)$  (b)  $h_1 - m(h_2 - h_1)$  (c)  $h_2 - m(h_2 - h_1)$  (d)  $m h_2 - (h_2 - h_1)$

43. For a given set of operating pressure limits of a Rankine cycle, the highest, efficiency occurs for

- (a) Saturated cycle (b) Superheated cycle (c) Reheat cycle (d) Regenerative cycle

44. In a 50% reaction stage, absolute velocity angle at inlet is  $45^\circ$  mean peripheral speed is 75 m/s and the absolute velocity at the exit is axial. The stage specific work is

- (a)  $2500 \text{ m}^2/\text{s}^2$  (b)  $3270 \text{ m}^2/\text{s}^2$  (c)  $4375 \text{ m}^2/\text{s}^2$  (d)  $5625 \text{ m}^2/\text{s}^2$

45. Which one of the following statements is correct?

(a) Efficiency of the Carnot cycle for thermal power plant is high and work ratio is also high in comparison to the Rankine cycle.

(b) Efficiency of the Carnot cycle is high and work ratio is low in comparison to the Rankine cycle.

(c) Efficiency of the Carnot cycle is low and work ratio is also low in comparison to the Rankine cycle.

- (d) Both the cycle have same efficiencies and work ratio.



46. According to Gibbs' phase rule, the number of degrees of freedom of an eutectic point in a binary system is  
(a) 1                      (b) 2                      (c) 0                      (d) 3

47. Decreasing grain size in a polycrystalline material  
(a) Increases yield strength and corrosion resistance.  
(b) Decreases yield strength and corrosion resistance  
(c) Decreases yield strength but increases corrosion resistance  
(d) Increases yield strength but decreases corrosion resistance.

48. When the temperature of a solid metal increases,  
(a) Strength of the metal decreases but ductility increases  
(b) Both strength and ductility of the metal decrease  
(c) Both strength and ductility of the metal increase  
(d) Strength of the metal increases but ductility decreases

49. Which one of the following factors is more relevant to represent complete solubility of two metals in each other?  
(a) Chemical affinity                      (b) Valency factor  
(c) Crystal structure factor                      (d) Relative size factor

50. Assertion (A): Elements are classified into metals and non-metals on the basis of their atomic weights.  
Reason (R): The valence electron structures contribute to the primary bonding between the atoms to form aggregates.  
(a) Both A and R are true and R is the correct explanation of A  
(b) Both A and R are true but R is NOT the correct explanation of A  
(c) A is true but R is false  
(d) A is false but R is true

51. Assertion (A): Unlike in the case of ionic bonds, the co-ordination numbers for covalently bonded atoms are not controlled by the radii ratio.  
Reason (R): A covalent bond has a specific direction of bonding in space.  
Both A and R are individually true and R is the correct explanation of  
(a) A  
Both A and R are individually true but R is not the correct  
(b) explanation of A  
(c) A is true but R is false

(d) A is false but R is true

52. Which of the following statement is true about brittle fracture?

- (a) High temperature and low strain rates favour brittle fracture  
Many metal with HCP crystal structure commonly show brittle
- (b) fracture
- (c) Brittle fracture is always preceded by noise
- (d) Cup and cone formation is characteristic for brittle materials

53. The statements concern Psychrometric chart.

1. Constant relative humidity lines are uphill straight lines to the right
2. Constant wet bulb temperature lines are downhill straight lines to the right
3. Constant specific volume lines are downhill straight lines to the right
4. Constant enthalpy lines are coincident with constant wet bulb temperature lines

Which of the statements are correct?

- (a) 2 and 3    (b) 1 and 2    (c) 1 and 3    (d) 2 and 4

54. Identify the wrong statement

- (a) Design of experiments reduces the number of experiments
- (b) Simulation gives the predicted results of the experiments
- (c) Empirical relations are not useful in engineering
- (d) Numerical relations are based on engineering data

55. Air ( $C_p = 1 \text{ KJ}$ ,  $\gamma = 1.4$ ) enters a compressor at a temperature of  $27^\circ\text{C}$ , the compressor pressure ratio is 4. Assuming an efficiency of 80%, the compressor work required in  $\text{KJ/Kg}$  is:

- (a) 160    (b) 172    (c) 182    (d) 225

56. A building has to be maintained at  $21^\circ\text{C}$  (dry bulb) and  $14.5^\circ\text{C}$ . The outside temperature is  $-23^\circ\text{C}$  (dry bulb) and the internal and external surface heat transfer coefficients are  $8 \text{ W/m}^2\text{K}$  and  $23 \text{ W/m}^2\text{K}$  respectively. If the building wall has a thermal conductivity of  $1.2 \text{ W/mK}$ , the minimum thickness (in m) of the wall required to prevent condensation is:

(a) 0.471 (b) 0.407 (c) 0.321 (d) 0.125

57. Two rods, one of length  $L$  and the other of length  $2L$  are made of the same material and have the same diameter. The two ends of the longer rod are maintained at  $100^\circ\text{C}$ . One end of the shorter rod maintained at  $100^\circ\text{C}$  while the other end is insulated. Both the rods are exposed to the same environment at  $40^\circ\text{C}$ . The temperature at the insulated end of the shorter rod is measured to be  $55^\circ\text{C}$ . The temperature at the midpoint of the longer rod would be:

(a)  $40^\circ\text{C}$  (b)  $50^\circ\text{C}$  (c)  $55^\circ\text{C}$  (d)  $100^\circ\text{C}$

58. A fin has 5mm diameter and 100 mm length. The thermal conductivity of fin material is  $400 \text{ Wm}^{-1}\text{K}^{-1}$ . One end of the fin is maintained at  $130^\circ\text{C}$  and its remaining surface is exposed to ambient air at  $30^\circ\text{C}$ . If the convective heat transfer coefficient is  $40 \text{ Wm}^{-2}\text{K}^{-1}$ , the heat loss (in W) from the fin is:

(a) 0.08 (b) 5.0 (c) 7.0 (d) 7.8

59. The value of Biot number is very small (less than 0.01) when

- (a) The convective resistance of the fluid is negligible
- (b) The conductive resistance of the fluid is negligible
- (c) The conductive resistance of the solid is negligible
- (d) None of these

60. A small copper ball of 5 mm diameter at 500 K is dropped into an oil bath whose temperature is 300 K. The thermal conductivity of copper is  $400 \text{ W/mK}$ , its density  $9000 \text{ kg/m}^3$  and its specific heat  $385 \text{ J/kg.K}$ . If the heat transfer coefficient is  $250 \text{ W/m}^2\text{K}$  and lumped analysis is assumed to be valid, the rate of fall of the temperature of the ball at the beginning of cooling will be, in K/s.

(a) 8.7 (b) 13.9 (c) 17.3 (d) 27.7

61. Tooth interference in an external involute spur gear pair can be reduced by

- (a) Decreasing center distance between gear pair
- (b) Decreasing module
- (c) Decreasing pressure angle
- (d) Increasing number of gear teeth

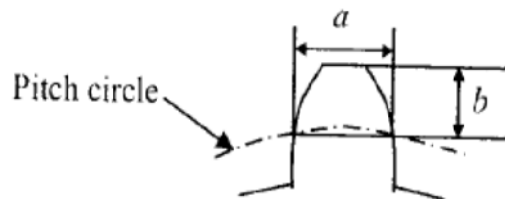
62. The ratio of tension on the tight side to that on the slack side in a flat belt drive is

- (a) Proportional to the product of coefficient of friction and lap angle
- (b) An exponential function of the product of coefficient of friction and lap angle.
- (c) Proportional to the lap angle
- (d) Proportional to the coefficient of friction

63. The percentage improvement in power capacity of a flat belt drive, when the wrap angle at the driving pulley is increased from  $150^\circ$  to  $210^\circ$  by an idler arrangement for a friction coefficient of 0.3, is

- (a) 25.21 (b) 33.92 (c) 40.17 (d) 67.85

64. One tooth of a gear having 4 module and 32 teeth is shown in the figure. Assume that the gear tooth and the corresponding tooth space make equal intercepts on the pitch circumference. The dimensions 'a' and 'b', respectively, are closest to



- (a) 6.08 mm, 4 mm (b) 6.48 mm, 4.2 mm (c) 6.28 mm, 4.3 mm (d) 6.28 mm, 4.1 mm

65. A spur gear has a module of 3 mm, number of teeth 16, a face width of 36 mm and a pressure angle of  $20^\circ$ . It is transmitting a power of 3 kW at 20 rev/s. Taking a velocity factor of 1.5, and a form factor of 0.3, the stress in the gear tooth is about

(a) 32 MPa   (b) 46 MPa   (c) 58 MPa   (d) 70MPa

66. All the following provide a different gear ratios except

- (a) manual Transmission
- (b) automatic transaxle
- (c) manual transaxle
- (d) clutch

67. The steps in any mechanical repair service may include

- (a) measuring and disassembly
- (b) machining and installing
- (c) reassembling and adjusting
- (d) all processes (a), (b) and (c)

68. The firing order in an internal combustion engine is the

- (a) order in which cylinders are numbered
- (b) order in which cylinders are placed
- (c) direction of rotation of crank shaft
- (d) sequence in which the cylinders deliver power stroke

69. The purpose of glow plug inside the combustion chamber is to

- (a) control idle engine speed
- (b) provide light inside the combustion chamber
- (c) add heat to the precombustion chamber
- (d) warm the fuel

70. A radiator like object is an example of

- (a) heat exchanger
- (b) defrosting device
- (c) expansion valve
- (d) heat pump

71. Find the false statement

- (a) Alcohol can be used as a fuel in an internal combustion engine
- (b) Air conditioner can be used as a heat pump
- (c) Stoichiometric combustion takes place inside the combustion chamber of an internal combustion engine
- (d) engines are designed to operate with lean combustion

72. Air fuel ratio for hydrocarbon fuels is around

- (a) 15:1 (b) 5:1 (c) 50:1 (d) any

73. Find the true statement

- (a) Modern vehicle engines have on board diagnostic capabilities
- (b) there are no strict emission laws in India
- (c) Motor vehicle act deals with designing of vehicles
- (d) hybrid fuel vehicles produce zero emission

74. If the demand for an item is doubled and the ordering cost halved, the economic order quantity

- (a) remains unchanged (b) increases by a factor of 2
- (c) is doubled (d) is halved

75. A welding operation is time-studied during which an operator was pace-rated as

120%. The operator took, on an average, 8 minutes for producing the weld-joint. If a total of 10% allowances are allowed for this operation, the expected standard production rate of the weld-joint (in units per 8 hour day) is

- (a) 45 (b) 50 (c) 55 (d) 60

76. In terms of Poisson's ratio( $\mu$ ) the ratio of Young's Modulus( $E$ ) to Shear Modulus( $G$ ) of Elastic material is

- (a)  $2(1+\mu)$  (b)  $2(1-\mu)$  (c)  $0.5(1+\mu)$  (d)  $0.5(1-\mu)$

77. A solid circular shaft of 60 mm diameter transmits a torque of 1600 N-m. The value of maximum shear stress developed is

- (a) 37.72 Mpa (b) 47.72 Mpa (c) 57.72 Mpa (d) 67.72 Mpa

78. An axial residual compressive stress due to a manufacturing process is present on the outer surface of a rotating shaft subjected to bending. Under a given bending load, the fatigue life of the shaft in the residual compressive stress is

- (a) Decreased  
(b) Increased or decreased, depending on the external bending load  
(c) Neither decreased nor increased  
(d) increased

79. The vibrating machine is isolated from the floor using springs, if the ratio of excitation frequency of vibration of machine to the natural frequency of the isolation system is equal to 0.5, transmissibility ratio of the isolation is

- (a)  $\frac{1}{2}$  (b)  $\frac{3}{4}$  (c)  $\frac{4}{3}$  (d) 2

80. The number of degree of freedom of a planer linkage with 8 links and 9 simple revolute joints is

(a) 1 (b) 2 (c) 3 (d) 4

81. A wire rope is designated as 6×19 standard hoisting. The numbers 6×19 represent

- (a) Diameter in millimeter × length in meter
- (b) Diameter in centimeter × length in meter
- (c) Number of strands × number of wires in each strand
- (d) Number of wires in each strand × number of strands

82. Two mating spur gears have 40 and 120 teeth respectively. The pinion rotates at 1200rpm and transmitted by gear is

(a) 6.6Nm (b) 20Nm (c) 40Nm (d) 60Nm

83. Twenty degree full depth involute profiled 19-tooth pinion and 37-tooth gear are in mesh.

If the module is 5mm, the center distance between the gear pair will be

(a) 140mm (b) 150mm (c) 280mm (d) 300mm

84. A ball bearing operating at a load  $F$  has 8000 hours of life. The life of the bearing, in hours, when the load is doubled to  $2F$  is

(a) 8000 (b) 6000 (c) 4000 (d) 1000

85. Two identical ball bearings P and Q are operating at loads 30KN and 45KN respectively. The ratio of the life of bearing P to the life of bearing Q is

(a) 81/16 (b) 27/8 (c) 9/4 (d) 3/2

86. For a Newtonian fluid

- (a) Shear stress is proportional to shear strain
- (b) Rate of shear stress is proportional to shear strain
- (c) Shear stress is proportional to rate of shear strain
- (d) Rate of shear stress is proportional to rate of shear strain

87. Consider an incompressible laminar boundary layer flow over a flat plate of length  $L$ , aligned with the direction of an incoming uniform free stream. If  $F$  is the ratio of the drag force on the front half of the plate to the drag force on the rear half, then

(a)  $F < \frac{1}{2}$  (b)  $F = \frac{1}{2}$  (c)  $F = 1$  (d)  $F > 1$



88. Consider steady laminar incompressible axi-symmetric fully developed viscous flow through a straight circular pipe of constant cross-sectional area at a Reynolds number of 5. The ratio of inertia force to viscous force on a fluid particle is

- (a) 5 (b)  $1/5$  (c) 0 (d) Infinite

89. The appropriate doping quantity of carbon nanotube required to improve the mechanical strength of a composite material is

- (a) less than 100% (b) less than 10% (c) less than 1% (d) any %

90. The unleaded petrol sold at filling stations in India contains

- (a) no lead content  
(b) less than 0.5 % lead content  
(c) more than 5.0%  
(d) no guidelines on the quantity of lead contents to oil companies