# 2. Design of Friction Drives

## Objective Questions (GATE, IES & IAS)

## Previous 20-Years GATE Questions

### Couplings

**GATE-1. The bolts in a rigid flanged coupling connecting two shafts transmitting power are subjected to [GATE-1996]**
(a) Shear force and bending moment (b) axial force.
(c) Torsion and bending moment (d) torsion

**GATE-1. Ans. (a)** The bolts are subjected to shear and bearing stresses while transmitting torque.



### Uniform pressure theory

**GATE-2. 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 [GATE-2008]**
(a) 148 Nm (b) 196 Nm (c) 372 Nm (d) 490 Nm

**GATE-2. Ans. (b)** $\text{Force(P)} = \frac{\pi p}{4}\left(D^2 - d^2\right)$

$$T = \frac{\mu P}{3}\cdot\frac{\left(D^3 - d^3\right)}{\left(D^2 - d^2\right)}$$

$$= \frac{\mu\pi}{12}.p.\left(D^3 - d^3\right) = \frac{0.4\times\pi\times 2\times 10^6}{12}\left(0.1^3 - 0.04^3\right) = 196\text{Nm}$$

**GATE-3. 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 [GATE-2006]**
(a) 39.4 mm (b) 49.5 mm (c) 97.9 mm (d) 142.9 mm

**GATE-3. Ans.(a)**

$$\text{Torque}, T = \frac{P\times 60}{2\pi\times N} = 23.87\,\text{N m}$$

$$= \text{Axial thrust}, W = P\times\pi(r_1^{\,2} - r_2^{\,2})$$

$$\text{But} \qquad T = \frac{2}{3}\mu\times P\times\pi(r_1^{\,2} - r_2^{\,2})\frac{(r_1^{\,3} - r_2^{\,3})}{(r_1^{\,2} - r_2^{\,2})} = \mu wr$$

$$\therefore \qquad r_2 = 39.4\,\text{mm}$$

## Belt and Chain drives

**GATE-4. Total slip will Occur in a belt drive when** **[GATE-1997]**

(a) Angle of rest is zero
(b) Angle of creep is zero
(c) Angle of rest is greater than angle of creep
(d) Angle of creep is greater than angle of rest

**GATE-4. Ans. (a)**

## Belt tension

**GATE-5. The ratio of tension on the tight side to that on the slack side in a flat belt drive is** **[GATE-2000]**

(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

**GATE-5. Ans. (b)**

$$\frac{T_1}{T_2} = \ell^{\mu 0}$$

**GATE-6. The difference between tensions on the tight and slack sides of a belt drive is 3000 N. If the belt speed is 15 m/s, the transmitted power in k W is**

(a) 45 (b) 22.5 (c) 90 (d) 100 **[GATE-1998]**

**GATE-6. Ans. (a)**

Given, $T_1 - T_2 = 3000N$

where $T_1 T_2$ = tensions on tight and slack side respectively

$v$ = belt speed = 15 m / sec

$$\text{Power} = (T_1 - T_2)v$$
$$= 3000 \times 45000 \text{ watt} = 45 \text{ kW}$$



**GATE-7. The percentage improvement in power capacity of a flat belt drive, when the wrap angle at the driving pulley is increased from 150° to 210° by an idler arrangement for a friction coefficient of 0.3, is** **[GATE-1997]**

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

**GATE-7. Ans. (d)** We know that Power transmitted (P) = $(T_1 - T_2).v$ W

Case-I: $\frac{T_1}{T_2} = e^{\mu\theta}$ or $\frac{T_1}{T_2} = e^{0.3\times\left(\frac{5\pi}{6}\right)}$ or $T_1 = 2.193\,T_2 \Rightarrow P_1 = 1.193 T_2 V$ W

Case-II: $\frac{T_1}{T_2} = e^{\mu\theta}$ or $\frac{T_1}{T_2} = e^{0.3\times\left(\frac{7\pi}{6}\right)}$ or $T_1 = 3.003\,T_2 \Rightarrow P_1 = 2.003 T_2 V$ W

Therefore improvement in power capacity $= \frac{P_2 - P_1}{P_1} \times 100\% = 67.88\%$

## Centrifugal tension

**GATE-8. With regard to belt drives with given pulley diameters, centre distance and coefficient of friction between the pulley and the belt materials, which of the statement below are FALSE?** **[GATE-1999]**

(a) A crossed flat belt configuration can transmit more power than an open flat belt configuration

**IES-8. Which of the following statements hold good for a multi-collar thrust bearing carrying an axial thrust of W units? [IES-1996]**
**1. Friction moment is independent of the number of collars.**
**2. The intensity of pressure is affected by the number of collars.**
**3. Co-efficient of friction of the bearing surface is affected by the number of collars.**
(a) 1 and 2 (b) 1 and 3 (c) 2 and 3 (d) 1, 2 and 3

**IES-8. Ans. (a)**

**IES-9. Which of the following statements regarding laws governing the friction between dry surfaces are correct? [IES-1996]**
**1. The friction force is dependent on the velocity of sliding.**
**2. The friction force is directly proportional to the normal force.**
**3. The friction force is dependent on the materials of the contact surfaces.**
**4. The frictional force is independent of the area of contact**
(a) 2, 3 and 4 (b) 1 and 3 (c) 2 and 4 (d) 1, 2, 3 and 4

**IES-9. Ans. (a)**

## Uniform pressure theory

**IES-10. Assertion (A):** In case of friction clutches, uniform wear theory should be considered for power transmission calculation rather than the uniform pressure theory.
**Reason (R):** The uniform pressure theory gives a higher friction torque than the uniform wear theory. **[IES-2003]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually 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



**IES-10. Ans. (b)** Uniform pressure theory is applicable only when the clutches are new i.e., the assumption involved is that axial force W is uniformly distributed.
Moreover torque transmitted in uniform pressure is more hence for safety in design uniform wear theory is used.

**IES-11. When the intensity of pressure is uniform in a flat pivot bearing of radius r, the friction force is assumed to act at [IES-2001]**
(a) r (b) r/2 (c) 2r/3 (d) r/3

**IES-11. Ans. (c)**

**IES-12. In a flat collar pivot bearing, the moment due to friction is proportional to ($r_1$ and $r_2$ are the outer and inner radii respectively) [IES-1993]**
(a) $\frac{r_1^2 - r_2^2}{r_1 - r_2}$ (b) $\frac{r_1^2 - r_2^2}{r_1 + r_2}$ (c) $\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}$ (d) $\frac{r_1^3 - r_2^3}{r_1 - r_2}$

**IES-12. Ans. (c)**

## Uniform wear theory

**IES-13. In designing a plate clutch, assumption of uniform wear conditions is made because [IES-1996]**
(a) It is closer to real life situation (b) it leads to a safer design.
(c) It leads to cost effective design (d) no other assumption is possible.

**IES-13. Ans. (a)**

## Multi-disk clutches

**IES-14. In case of a multiple disc clutch, if $n_1$ is the number of discs on the driving shaft and $n_2$ is the number of discs on the driven shaft, then what is the number of pairs of contact surfaces? [IES-2008]**

(a) $n_1 + n_2$ (b) $n_1 + n_2 - 1$ (c) $n_1 + n_2 + 1$ (d) $n_1 + 2n_2$

**IES-14. Ans. (b)**

**IES-15. In a multiple disc clutch if $n_1$ and $n_2$ are the number of discs on the driving and driven shafts, respectively, the number of pairs of contact surfaces will be [IES-2001; 2003]**

(a) $n_1 + n_2$ (b) $n_1 + n_2 - 1$ (c) $n_1 + n_2 + 1$ (d) $\frac{n_1 + n_2}{2}$

**IES-15. Ans. (b)**

**IES-16. In the multiple disc clutch, If there are 6 discs on the driving shaft and 5 discs on the driven shaft, then the number of pairs of contact surfaces will be equal to [IES-1997]**

(a) 11 (b) 12 (c) 10 (d) 22

**IES-16. Ans. (c)** No. of active plates = 6 + 5 - 1 = 10



## Cone clutches

**IES-17. Which one of the following is the correct expression for the torque transmitted by a conical clutch of outer radius R, Inner radius r and semi-cone angle $\alpha$ assuming uniform pressure? (Where W = total axial load and $\mu$ = coefficient of friction) [IES-2004]**

(a) $\frac{\mu W(R + r)}{2\sin\alpha}$ (b) $\frac{\mu W(R + r)}{3\sin\alpha}$

(c) $\frac{2\mu W(R^3 - r^3)}{3\sin\alpha(R^2 - r^2)}$ (d) $\frac{3\mu W(R^3 - r^3)}{4\sin\alpha(R^2 - r^2)}$

**IES-17. Ans. (c)**

## Centrifugal clutches

**IES-18. On the motors with low starting torque, the type of the clutch to be used is [IES-2003]**

(a) Multiple-plate clutch (b) Cone clutch
(c) Centrifugal clutch (d) Single-plate clutch with both sides effective

**IES-18. Ans. (c)**

**IES-19. Consider the following statements regarding a centrifugal clutch:**
**It need not be unloaded before engagement. [IES-2000]**
**1. It enables the prime mover to start up under no-load conditions.**
**2. It picks up the load gradually with the increase in speed**
**3. It will not slip to the point of destruction**
**4. It is very useful when the power unit has a low starting torque**
**Which of these are the advantages of centrifugal clutch?**

(a) 1, 2 and 4 (b) 1, 3 and 5 (c) 2, 3 and 5 (d) 1, 3, 4 and 5

**IES-19. Ans. (c)**

**IES-20. Match List-I with List-II and select the correct answer using the codes given below the lists: [IES-1998]**

**List-I** **List-II**

**IES-55. Given that W = weight of load handled, $W_r$ = weight of rope and f = acceleration, the additional load in ropes of a hoist during starting is given by [IES-1997]**

$$(a)\ F_a = \left(\frac{W - W_r}{g}\right) f \qquad (b)\ F_a = \left(\frac{W + W_r}{g}\right) f \qquad (c)\ F_a = \frac{W}{g} f \qquad (d)\ F_a = \frac{W_r}{g} f$$

**IES-55Ans. (b)**

**IES-56. Effective stress in wire ropes during normal working is equal to the stress due to [IES-1996]**

(a) Axial load plus stress due to bending.
(b) Acceleration / retardation of masses plus stress due to bending.
(c) Axial load plus stress due to acceleration / retardation.
(d) bending plus stress due to acceleration/retardation.

**IES-56Ans. (a)**

**IES-57. When compared to a rod of the same diameter and material, a wire rope**

(a) Is less flexible **[IES-1994]**
(b) Has a much smaller load carrying capacity.
(c) Does not provide much warning before failure.
(d) Provides much greater time for remedial action before failure.

**IES-57Ans. (d)** A wire rope provides much greater time for remedial action before failure.



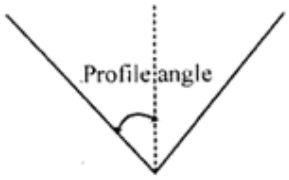
## Types of power screw

**IES-58. Power screws are used to produce uniform, slow and powerful motion such as required in presses, jacks and other machinery. 'V' threads are usually *not* used for this application due to low efficiency. This is because:**

(a) Profile angle is zero (b) Profile angle is moderate **[IES-2005]**
(c) Profile angle is large (d) There is difficulty in manufacturing the profile

**IES-58.Ans. (c)**

Square thread most efficient. Profile angle is zero which causes excessive bursting force.




**IES-59. Consider the following statements regarding power screws: [IES-1994]**
**1. The efficiency of a self-locking screw cannot be more than 50%.**
**2. If the friction angle is less than the helix angle of the screw, then the efficiency will be more than 50%.**
**3. The efficiency of ACME (trapezoidal thread) is less than that of a square thread.**
**Of these statements**

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

**IES-59Ans. (c)**

**IES-60. Assertion (A):** Buttress thread is a modified square thread profile which is employed on the lead screw of machine tools. **[IES-2001]**
**Reason (R):** Frequent engagement and disengagement of lead screw for automatic feed is not possible with perfect square threads, therefore, the square profile has to be modified.

(a) Both A and R are individually true and R is the correct explanation of A

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

**IAS-6Ans. (c)**

**GATE-28. To make a worm drive reversible, it is necessary to increase [GATE-1997]**
(a) centre distance (b) worm diameter factor
(c) Number of starts (d) reduction ratio
**GATE-28Ans. (c)**

## Previous 20-Years IES Questions

## Spur gear

**IES-1. The velocity ratio between pinion and gear in a gear drive is 2.3, the module of teeth is 2.0 mm and sum of number of teeth on pinion and gear is 99. What is the centre distance between pinion and the gear? [IES 2007]**

(a) 49.5 mm (b) 99 mm (c) 148.5 mm (d) 198 mm

**IES-1. Ans. (b)** Centre distance = $\frac{D_1 + D_2}{2} = \frac{mT_1 + mT_2}{2} = \frac{m}{2}(T_1 + T_2) = \frac{2}{2} \times 99 = 99$ mm

**IES-2. Consider the following statements: [IES-2001]**
**When two gears are meshing, the clearance is given by the**
**1. Difference between dedendum of one gear and addendum of the mating gear.**
**2. Difference between total and the working depth of a gear tooth.**
**3. Distance between the bottom land of one gear and the top land of the mating gear.**
**4. Difference between the radii of the base circle and the dedendum circle.**
**Which of these statements are correct?**
(a) 1, 2 and 3 (b) 2, 3 and 4 (c) 1, 3 and 4 (d) 1, 2 and 4
**IES-2. Ans. (a)**

**IES-3. The working surface above the pitch surface of the gear tooth is termed as [IES-1998]**
(a) Addendum (b) dedendum (c) flank (d) face
**IES-3. Ans. (d)**

**IES-4. Match the following $14\frac{1}{2}^{o}$ composite system gears [IES-1992]**

| List I | List II |
|---|---|
| A. Dedendum | 1. $\frac{2}{pd}$ |
| B. Clearance | 2. $\frac{0.157}{pd}$ |
| C. Working depth | 3. $\frac{1.157}{pd}$ |
| D. Addendum | 4. $\frac{1}{pd}$ |

| Code: | A | B | C | D | | A | B | C | D |
|---|---|---|---|---|---|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 | (b) | 4 | 3 | 2 | 1 |
| (c) | 3 | 2 | 1 | 4 | (d) | 3 | 1 | 2 | 4 |

Circular pitch $= \frac{\pi d}{T} = \pi \times 6 = 18.84$ mm ; addendum = 1 module = 6 mm

diametral pitch $= \frac{T}{d} = \frac{1}{6}$

Circular pitch = - = 1t X 6 = 18.84 mm

**IES-26. Which of the following statements are correct? [IES-1996]**

1. For constant velocity ratio transmission between two gears, the common normal at the point of contact must always pass through a fixed point on the line joining the centres of rotation of the gears.
2. For involute gears the pressure angle changes with change in centre distance between gears.
3. The velocity ratio of compound gear train depends upon the number of teeth of the input and output gears only.
4. Epicyclic gear trains involve rotation of at least one gear axis about some other gear axis.

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

**IES-26Ans. (c)**

**IES-27. Which one of the following is true for involute gears? [IES-1995]**

(a) Interference is inherently absent
(b) Variation in centre distance of shafts increases radial force
(c) A convex flank is always in contact with concave flank
(d) Pressure angle is constant throughout the teeth engagement.

**IES-27Ans. (d)** For involute gears, the pressure angle is constant throughout the teeth engagement.



**IES-28. In involute gears the pressure angle is [IES-1993]**

(a) Dependent on the size of teeth (b) dependent on the size of gears
(c) Always constant (d) always variable

**IES-28Ans. (c)** The pressure angle is always constant in involute gears.

## Minimum Number of Teeth

**IES-29. Which one of the following statements is correct? [IES-2004]**

Certain minimum number of teeth on the involute pinion is necessary in order to

(a) Provide an economical design (b) avoid Interference
(c) Reduce noise in operation (d) overcome fatigue failure of the teeth

**IES-29Ans. (b)**

**IES-30. A certain minimum number of teeth is to be kept for a gear wheel**

(a) So that the gear is of a good size **[IES-1999]**
(b) For better durability
(c) To avoid interference and undercutting
(d) For better strength

**IES-30Ans. (c)**

**IES-31. In full depth $14\frac{1}{2}^{o}$ degree involute system, the smallest number of teeth in a pinion which meshes with rack with out interference is [IES-1992]**

(a) 12 (b) 16 (c) 25 (d) 32

**IES-32Ans. (d)**

**4. The point on the disc making contact with the plane surface has zero acceleration of these statements**

(a) 1 and 4 are correct (b) 3 and 4 are correct
(c) 3 alone is correct (d) 2 alone is correct.

**IES-37.Ans. (d)**

## Involute teeth

**IES-38. In the case of an involute toothed gear, involute starts from [IES-1997]**

(a) Addendum circle (b) dedendum circle
(c) Pitch circle (d) base circle

**IES-38Ans. (b)**

**IES-39. Consider the following statements: [IES-2006]**

**1. A stub tooth has a working depth larger than that of a full-depth tooth.**
**2. The path of contact for involute gears is an arc of a circle.**
**Which of the statements given above is/are correct?**

(a) Only 1 (b) Only 2 (c) Both 1 and 2 (d) Neither 1 nor 2

**IES-39Ans. (d)** 1. A stub tooth has a working depth lower than that of a full-depth tooth.
2. The path of contact for involute gears is a line.

**IES-40. Consider the following statements regarding the choice of conjugate teeth for the profile of mating gears: [IES-1999]**

**1. They will transmit the desired motion**
**2. They are difficult to manufacture.**
**3. Standardisation is not possible**
**4. The cost of production is low**
**Which of these statements are correct?**

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

**IES-40Ans. (a)** Cost of production of conjugate teeth, being difficult to manufacture is high.

**IES-41. Which one of the following is correct? [IES-2008]**

**When two teeth profiles of gears are conjugate, the sliding velocity between them**

(a) Is always zero, all through the path of contact?
(b) Is zero, at certain points along the path of contact?
(c) Is never zero anywhere on the path of contact?
(d) Can be made zero by proper selection of profiles

**IES-41Ans. (a)**

## Contact ratio

**IES-42. Which one of the following is the correct statement? [IES 2007]**

**In meshing gears with involute gears teeth, the contact begins at the intersection of the**

(a) Line of action and the addendum circle of the driven gear
(b) Line of action and the pitch circle of the driven gear
(c) Dedendum circle of the driver gear and the addendum circle of the driven gear
(d) Addendum circle of the driver gear and the pitch circle of the driven gear

**IES-42Ans. (a)**

**IES-43. Common contact ratio of a pair of spur pinion and gear is [IES-2008]**

(a) Less than 1·0 (b) equal to 1
(c) Between 2 and 3 (d) greater than 3

**IES-43Ans. (c)** The ratio of the length of arc of contact to the circular pitch is known as **contact ratio** i.e. number of pairs of teeth in contact. The contact ratio for gears is greater than one. Contact ratio should be at least 1.25. For maximum smoothness and quietness, the contact ratio should be between 1.50 and 2.00. High-speed applications should be designed with a face-contact ratio of 2.00 or higher for best results.

## Interference

**IES-44. Interference between an involute gear and a pinion can be reduced by which of the following? [IES-2008]**
**1. Increasing the pressure angle of the teeth in the pair, the number of teeth remaining the same.**
**2. Decreasing the addendum of the gear teeth and increasing the same for the pinion teeth by the corresponding amount.**
**Select the correct answer using the code given below:**
(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

**IES-44Ans. (c)**

**IES-45. In gears, interference takes place when [IES-1993]**
(a) The tip of a tooth of a mating gear digs into the portion between base and root circles
(b) Gears do not move smoothly in the absence of lubrication
(c) Pitch of the gear is not same
(d) gear teeth are undercut

**IES-45Ans. (a)** In gears, interference takes place when the tip of a tooth of a mating gear digs into the portion between base and root circle.



**IES-46. An involute pinion and gear are in mesh. If both have the same size of addendum, then there will be an interference between the [IES-1996]**
(a) Tip of the gear tooth and flank of pinion.
(b) Tip of the pinion and flank of gear.
(c) Flanks of both gear and pinion.
(d) Tips of both gear and pinion.

**IES-46Ans. (a)**

**IES-47. Interference between the teeth of two meshing involute gears can be reduced or eliminated by [IES 2007]**
**1. Increasing the addendum of the gear teeth and correspondingly reducing the addendum of the pinion.**
**2. Reducing the pressure angle of the teeth of the meshing gears.**
**3. Increasing the centre distance**
**Which of the statements given above is/are correct?**
(a) 1 and 2 (b) 2 and 3
(c) 1 only (d) 3 only

**IES-47Ans. (d)**

**IES-48. Consider the following statements: [IES-2002]**
**A $20^{o}$ stub tooth system is generally preferred in spur gears as it results in**
**1. Stronger teeth**
**2. Lesser number of teeth on the pinion**
**3. Lesser changes of surface fatigue failure**
**4. Reduction of interference**
**Which of the above statements are correct?**

**IES-59. Consider the following statements:**
**The form factor of a spur gear tooth depends upon the** **[IES-1996]**
**1. Number of teeth** **2. Pressure angle**
**3. Addendum modification coefficient** **4. Circular pitch**
**Of these correct statements are**
(a) 1 and 3 (b) 2 and 4 (c) 1, 2 and 3 (d) 1 and 4

**IES-59Ans. (c)**

**IES-60. Assertion (A):** If the helix angle of a helical gear is increased, the load carrying capacity of the tooth increases. **[IES-1996]**
**Reason (R):** The form factor of a helical gear increases with the increasing in the helix angle.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually 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

**IES-61Ans. (a)**

**IES-62. Match List I with List II and select the correct answer using the codes given below the Lists:** **[IES-2000]**

| List I | List II |
|---|---|
| A. Unwin's formula | 1. Bearings |
| B. Wahl factor | 2. Rivets |
| C. Reynolds's equation | 3. Gears |
| D. Lewis form factor | 4. Springs |

| Codes: | A | B | C | D | | A | B | C | D |
|---|---|---|---|---|---|---|---|---|---|
| (a) | 1 | 4 | 2 | 3 | (b) | 2 | 3 | 1 | 4 |
| (c) | 1 | 3 | 2 | 4 | (d) | 2 | 4 | 1 | 3 |

**IES-62Ans. (d)**

**IES-62. A spur gear transmits 10 kW at a pitch line velocity of 10 m/s; driving gear has a diameter of 1.0 m. Find the tangential force between the driver and the follower, and the transmitted torque respectively.** **[IES-2009]**
(a) 1 kN and 0.5 kN-m (b) 10 kN and 5 kN-m
(c) 0.5 kN and 0.25 kN-m (d) 1 kN and 1 kN-m

**IES-62Ans. (a)** Power transmitted = Force × Velocity

$$\Rightarrow \quad 10\times10^{3} = \text{Force}\times10$$

$$\Rightarrow \quad \text{Force} = \frac{10\times10^{3}}{10} = 1000\ \text{N/m}$$

$$\text{Torque Transmitted} = \text{Force}\times\frac{\text{diameter}}{2}$$

$$= 1000\times\frac{1}{2} = 1000\times0.5$$

$$= 500\,\text{N}-\text{m} = 0.5\ \text{kN}-\text{m}$$

## Wear Strength of Gear Tooth

**IES-63. The limiting wear load of spur gear is proportional to (where $E_p$ = Young's modulus of pinion material; $E_g$ = Young's modulus of gear material)** **[IES-1997]**

**IES-85.** **Assertion (A):** Helical gears are used for transmitting motion and power between intersecting shafts, whereas straight bevel gears arc used for transmitting motion and power between two shafts intersecting each other at 90°. **[IES-2000]**
**Reason (R):** In helical gears teeth are inclined to axis of the shaft and arc in the form or a helix.
Where as in bevel gears, teeth arc tapered both in thickness and height form one end to the other.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually 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

**IES-85Ans. (d)**

**IES-86.** **Assertion (A):** Shafts supporting helical gears must have only deep groove ball-bearings. **[IES-1999]**
**Reason (R):** Helical gears produce axial thrusts.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually 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

**IES-86Ans. (a)**

**IES-87.** **Assertion (A):** Crossed helical gears for skew shafts are not used to transmit heavy loads. **[IES-1995]**
**Reason (R)** The gears have a point contact, and hence are not considered strong.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually 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

**IES-87Ans. (b)**



## Bevel Gears

**IES-88.** **In a differential mechanism, two equal sized bevel wheels A and B are keyed to the two halves of the rear axle of a motor car. The car follows a curved path. Which one of the following statements is correct? [IES-2004]**
The wheels A and B will revolve at different speeds and the casing will revolve at a speed which is equal to the
(a) Difference of speeds of A and B
(b) Arithmetic mean of speeds of A and B
(c) Geometric mean of speeds of A and B
(d) Harmonic mean of speeds of A and B

**IES-88Ans. (d)**

## Worm Gears

**IES-89.** **Assertion (A):** Tapered roller bearings must be used in heavy duty worm gear speed reducers. **[IES-2005]**
**Reason (R):** Tapered roller bearings are suitable for large radial as well as axial loads.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false

**IAS-10Ans. (d)** contact ratio= $\frac{length\ of\ are\ of\ contant}{circular\ pitch}$

$$=\frac{\sqrt{R_{A^2}-R^2\cos^2\theta}+\sqrt{r_{A^2}-r^2\cos^2\theta}-(R+r)\sin\theta}{P_c(\cos\theta)}$$

**IAS-11. The velocity of sliding of meshing gear teeth is** **[IAS-2002]**

(a) $(\omega_1\times\omega_2)x$ (b) $\frac{\omega_1}{\omega_2}x$ (c) $(\omega_1+\omega_2)x$ (d) $\frac{(\omega_1+\omega_2)}{x}$

(Where $\omega_1$ and $\omega_2$ = angular velocities of meshing gears
x = distance between point of contact and the pitch point)

**IAS-11Ans. (c)**

# Interference

**IAS-12. For spur with gear ratio greater than one, the interference is most likely to occur near the** **[IAS-1997]**

(a) Pitch point (b) point of beginning of contact
(c) Point of end of contact (d) root of the tooth

**IAS-12Ans. (d)**

**IAS-13. How can interference in involute gears be avoided?** **[IAS-2007]**

(a) Varying the centre distance by changing the pressure angle only
(b) Using modified involute as composite system only
(c) Increasing the addendum of small wheel and reducing it for the larger wheel only
(d) Any of the above

**IAS-13Ans. (d)**

**IAS-14. Which one of the following statements in respect of involute profiles for gear teeth is not correct?** **[IAS-2003]**

(a) Interference occurs in involute profiles,
(b) Involute tooth form is sensitive to change in centre distance between the base circles.
(c) Basic rack for involute profile has straight line form
(d) Pitch circle diameters of two mating involute gears are directly proportional to the base circle diameter

**IAS-14Ans. (b)**

**IAS-15. Assertion (A):** In the case of spur gears, the mating teeth execute pure rolling motion with respect to each other from the commencement of engagement to its termination. **[IAS-2003]**

**Reason (R):** The involute profiles of the mating teeth are conjugate profiles which obey the law of gearing.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually 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

**IAS-15Ans. (a)**

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

**IES-6Ans. (a)**

**IES-7. Which one of the following statements is correct? [IES-2004]**
**Antifriction bearings are**
(a) Sleeve bearings (b) gas lubricated bearings
(c) Ball and roller bearings (d) journal bearings

**IES-7Ans. (c)**

**IES-8. The rolling element bearings are [IES-2003]**
(a) Hydrostatic bearings (b) Squeeze film bearings
(c) Antifriction bearings (d) Grease lubrication bearings

**IES-8Ans. (c)**

**IES-9. A ball-bearing is characterized by basic static capacity = 11000 N and dynamic capacity = 18000 N. This bearing is subjected to equivalent static load = 5500 N. The bearing loading ratio and life in million revolutions respectively are [IES-2001]**
(a) 3.27 and 52.0 (b) 3.27 and 35.0 (c) 2.00 and 10.1 (c) 1.60 and 4.1

**IES-9Ans. (b)** $Loading\ ratio = \frac{C}{P} = \frac{18000}{5500} = 3.27$

Life (million revolutions)

$$= \left(\frac{C}{P}\right)^3 = \left(\frac{18000}{5500}\right)^3 = 35$$



**IES-10. On what does the basic static capacity of a ball bearing depends? [IES-2009]**
(a) Directly proportional to number of balls in a row and diameter of ball
(b) Directly proportional to square of ball diameter and inverse of number of rows of balls
(c) Directly proportional to number of balls in a row and square of diameter of ball
(d) Inversely proportional to square of diameter of ball and directly proportional to number of balls in a row

**IES-10Ans. (c)**

**IES-11. Ball bearings are provided with a cage [IES-1992]**
(a) To reduce friction
(b) To maintain the balls at a fixed distance apart
(c) To prevent the lubricant from flowing out
(d) To facilitate slipping of balls

**IES-11Ans. (b)**

**IES-12. In a single row deep groove ball-bearing, cages are needed to [IES-1999]**
(a) Separate the two races
(b) Separate the balls from the inner race
(c) Separate the outer race from the balls
(d) Ensure that the balls do not cluster at one point and maintain proper relative angular positions.

**IES-12Ans. (d)**

**IES-13. Which one of the following statements is NOT true of rolling contact bearing? [IES-1997]**
(a) The bearing characteristic number is given by ZN/p where Z is the absolute viscosity of the lubricant, N is the shaft speed and p is the bearing pressure.

(c) Bearing metal temperature and oil pressure
(d) Oil pressure and bearing vibration

**IES-42Ans. (a)**

**IES-43. Consider the following pairs of types of bearings and applications:**
**1. Partial Journal bearing..... Rail wagon axles [IES-2000]**
**2. Full journal bearing .....Diesel engine crank-shaft**
**3. Radial bearing .....Combined radial and axial loads**
**Which of these pairs is/are correctly matched?**
(a) 1 alone (b) 1 and 2 (c) 2 and 3 (d) 1, 2 and 3

**IES-43Ans. (b)**

**IES-44. Match List I with List II and select the correct answer using the code given below the lists: [IES-1995]**

| List I (Requirement) | List II (Type) |
|---|---|
| A. High temperature service | 1. Teflon bearing. |
| B. High load | 2. Carbon bearing |
| C. No lubrication | 3. Hydrodynamic bearing |
| D. Bushings | 4. Sleeve bearing |

| Codes: | A | B | C | D | | A | B | C | D |
|---|---|---|---|---|---|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 | (b) | 4 | 1 | 2 | 3 |
| (c) | 2 | 1 | 3 | 4 | (d) | 2 | 3 | 1 | 4 |

**IES-44Ans. (d)**

**IES-45. Assertion (A):** In anti-friction bearings, the frictional resistance is very low as the shaft held by it remains in floating condition by the hydrodynamic pressure developed by the lubricant. **[IES-2006]**
**Reason (R):** In hydrodynamic journal bearings, hydrodynamic pressure is developed because of flow of lubricant in a converging -diverging channel
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually 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

**IES-45Ans. (d)**

**IES-46. Satisfactory hydrodynamic film in a journal bearing is formed when**
(a) Journal speed is low, unit pressure on the bearing is high and viscosity of lubricant used is low **[IES-2006]**
(b) Journal speed is low, unit pressure on the bearing is low and viscosity of lubricant used is low
(c) Journal speed is high, unit pressure on the bearing is high and viscosity of lubricant used is high
(d) Appropriate combination of journal speed, unit pressure on bearing and lubricant viscosity exists resulting in low coefficient of friction

**IES-46Ans. (c)**

**IES-47. In an oil-lubricated journal bearing, coefficient of friction between the journal and the bearing. [IES-1995]**
(a) Remains constant at all speeds.
(b) is minimum at zero speed and increases monotonically with increase in speed.
(c) is maximum at zero speed and decreases monotonically with increase in speed.
(d) becomes minimum at an optimum speed and then increases with further increase in speed.

**IES-47Ans. (d)**

| (Mechanical Property) | (Measured in Terms of) |
|---|---|
| (A) Strength (Fluctuating load) | 1. Percentage elongation |
| (B) Toughness | 2. Modulus of elasticity |
| (C) Stiffness | 3. Endurance limit |
| (D) Ductility | 4. Impact strength |

| Codes: | A | B | C | D | | A | B | C | D |
|---|---|---|---|---|---|---|---|---|---|
| (a) | 2 | 1 | 3 | 4 | (b) | 3 | 4 | 2 | 1 |
| (c) | 2 | 4 | 3 | 1 | (d) | 3 | 1 | 2 | 4 |

**IAS 5. Ans. (b)**

**IAS 6.** **Match List I with List II and select the correct answer:** **[IAS-2000]**

| List I | List II |
|---|---|
| A. Proof stress | 1. Torsion test |
| B. Endurance limit | 2. Tensile test |
| C. Leaf Spring | 3. Fatigue test |
| D. Modulus of rigidity | 4. Beam of uniform strength |

| | A | B | C | D | | A | B | C | D |
|---|---|---|---|---|---|---|---|---|---|
| (a) | 2 | 3 | 4 | 1 | (b) | 2 | 3 | 1 | 4 |
| (c) | 3 | 2 | 4 | 1 | (d) | 3 | 2 | 1 | 4 |

**IAS 6. Ans. (a)**