

TWO MARKS Q & A

"Education is not a product : mark, degree, job, money – in that order; it is a process, a never-ending one."

– Bel Kaufman

CHAPTER – 1 : FLAT BELT AND PULLEYS

1. **Name the four types of belts used for transmission of power.**

1. Flat belts ;
2. V-belts ;
3. Ribbed belts ; and
4. Toothed or timing belts.

2. **Differentiate between open drive and cross drive of a belt drive.**

✓ **Open belt drive** : Used with shafts arranged parallel and rotating in same direction.

✓ **Cross belt drive** : Used with shafts arranged parallel and rotating in opposite direction.

3. **Why are idler pulleys used in a belt drive ?**

✓ Idler pulleys are provided to obtain high velocity ratio.

✓ Many idler pulleys are used when it is desired to transmit motion from one shaft to several parallel shafts.

4. **When do you use stepped pulley drive ?**

A stepped or cone pulley drive is used for changing the speed of the driven shaft while the driving shaft runs at constant speed.

5. **When do you use fast and loose pulley drive ?**

A fast and loose pulley drive is used when the driven or machine shaft is to be started or stopped whenever desired without interfering with the driving shaft.

6. **What are the materials used for belt drive ?**

1. Leather,
2. Fabric and cotton,
3. Rubber,
4. Balata,
- and 5. Nylon.

7. **Define velocity ratio of a belt drive.**

It is the ratio between velocity of the driver and the follower or driven.

8. **Whether the thickness of a belt affects the velocity ratio ?**

Yes, but it is negligible.

Velocity ratio, $\frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}$ where t = Belt thickness.

9. **Define slip of a belt. What is the effect of slip on velocity ratio of a belt drive ?**

✓ Slip is defined as the relative motion between the belt and pulley.

✓ Velocity ratio, $\frac{N_2}{N_1} = \frac{d_1}{d_2} \left[1 - \frac{S}{100} \right]$ where S = Slip of the belt drive.

10. Why the phenomenon of creep results in a belt drive ?

The phenomenon of sudden contraction and expansion of belt when it passes from slack side to tight side is called as creep.

11. State the law of belting ?

Law of belting states that the centre line of the belt as it approaches the pulley must lie in a plane perpendicular to the axis of that pulley or must lie in the plane of the pulley, otherwise the belt will run off the pulley.

12. What is meant by ply in a flat belt ?

Belts are specified according to the number of layers, e.g., single-ply, double-ply or triple-ply.

13. What are the factors on which the coefficient of friction between the belt and pulley depend ?

- 1. Material of belt ;
- 2. Material of pulley ;
- 3. Slip of belt ; and
- 4. Speed of belt.

14. In an open belt drive, which side of the belt is tight, whether upper side or lower side ? Why ?

- ✓ In an open belt drive, the lower side of the belt is tight.
- ✓ Because the driving pulley pulls the belt from lower side and delivers it to the upper side. So it is obvious that the lower side of the belt is tight.

15. What is centrifugal effect on belts ?

- ✓ In operation, as the belt passes over the pulley the centrifugal effect due to its self weight tends to lift the belt from the pulley surface. This reduces the normal reaction and hence the frictional resistance.
- ✓ The centrifugal force produces an additional tension in the belt.

16. Centrifugal tension in a belt drive _____ the power transmitted.

[Ans : will not effect]

17. Centrifugal tension has no effect on the power transmitted. Justify the statement.

When centrifugal tension is taken into account,

then total tension in the tight side, $T_{t1} = T_1 + T_C$

and total tension in the slack side, $T_{t2} = T_2 + T_C$

We know that, power transmitted, $P = (T_{t1} - T_{t2}) v$

$$= [(T_1 + T_C) - (T_2 + T_C)] v$$

$$= (T_1 - T_2) v$$

Thus, the centrifugal tension has no effect on the power transmitted.

18. **What is initial tension in belt drives ?**

The tension of the belt when a belt is fitted to a pair of pulleys when the system is stationary, is termed as initial tension of the belt.

19. **Power transmitted by a belt drive without considering the initial tension, is maximum when the tight side tension is equal to _____ times the centrifugal tension.**

[Ans : three]

20. **What will be the effect on the limiting ratio of tensions of a belt if the coefficient of friction between the belt and rim of pulley is doubled while angle of lap remains same ?**

[Ans : The ratio of tension will be squared]

21. **What are the losses in belt drives ?**

The losses in a belt drive are due to :

- (i) Slip and creep of the belt on the pulleys,
- (ii) Windage or air resistance to the movement of belt and pulleys,
- (iii) Bending of the belt over the pulleys, and
- (iv) Friction in the bearings of pulley.

22. **A longer belt will last more than a shorter belt. Why ?**

The life of a belt is a function of the centre distance between the driver and driven shafts. The shorter the belt, the more often it will be subjected to additional bending stresses while running around the pulleys at a given speed, and quicker it will be destroyed due to fatigue. Hence, a longer belt will last more than a shorter belt.

23. **What is wipping ? How it can be avoided in belt drives ?**

✓ If the centre distance between two pulleys are too long then the belt begins to vibrate in a direction perpendicular to the direction of motion of belt. This phenomenon is called as wipping.

✓ Wipping can be avoided by using idlers pulleys.

24. **Crowning is done on a pulley to _____ the tendency of the belt to slip.**

[Ans : reduce]

25. **What is crowning of pulley ? (or) why the face of a pulley is crowned ?**

✓ The pulley rims are tapered slightly towards the edges. This slight convexity is known as crowning.

✓ The crowning tends to keep the belt in centre on a pulley rim while in motion.

26. **List the different types of pulleys used in belt drives.**

- (i) Solid pulleys, and (ii) Split pulleys.

27. *What are the materials used for pulleys ?*

- ✓ Cast iron, ✓ Fabricated steel,
- ✓ Compressed paper, ✓ Wood or fibre.

28. *In designing a belt drive, if both driving and driven pulleys are of same material, then _____ pulley governs the design. [Ans : smaller]*

CHAPTER – 2 : V-BELTS

1. *What type of belt would you prefer if the centre distance between the pulleys is small ?*
V-belt.

2. *State reasons for V-belt drive being preferred to flat belt drive ?*

V-belt drive is preferred to flat belt drive due to the following advantages :

- ✓ Power transmitted is more due to wedging action in the grooved pulley.
- ✓ Higher velocity ratio (upto 10) can be obtained.
- ✓ V-belt drive is more compact, quiet and shock absorbing.
- ✓ The drive is positive because the slip is negligible.

3. *Why slip is less in the case of V-belts when compared with flat belts ?*

The slip is less due to the wedging action in the grooved pulley.

4. *The included angle for V-belt groove is usually between _____ and _____ degrees. [Ans : 32° ; 38°]*

5. *The included angle for the V-belt is usually _____. [Ans : 30° to 40°]*

6. *What are the different cross sections of a V-belt ?*

A, B, C, D and E type V-belts.

7. *How can you specify (or designate) V-belts ?*

V-belts are designated by its type and nominal inside length.

8. *How will you determine the number of belts required in the design of V-belt drives ?*

$$\text{Number of V-belts} = \frac{\text{Total power transmitted}}{\text{Power transmitted per belt}}$$

9. *What is a 'V-flat' drive ?*

In V-belt drive, if the large grooved pulley is replaced by a flat faced pulley (and smaller pulley remains V-grooved), then the drive is known as V-flat drive.

10. *What are the materials used for V-grooved pulleys ?*

Cast iron, pressed steel, formed steel and die cast aluminium.

CHAPTER – 3 : WIRE ROPES AND PULLEYS

1. *When do you prefer a wire rope drive ?*

Wire ropes are preferred whenever large power is to be transmitted over long distances (upto 150 m).

2. *Write any four wire rope applications.*

Wire ropes are extensively used in elevators, mine hoists, cranes, conveyors, and suspension bridges.

3. *What are the advantages of wire ropes when compared with chains and fibre ropes ?*

The advantages of wire ropes are :

- ✓ Lighter weight and high strength to weight ratio.
- ✓ More reliable in operation.
- ✓ Silent operation even at high working speeds.
- ✓ Less danger for damage due to jerks.

4. *Distinguish regular-lay and lang-lay ropes.*

(i) *Regular lay ropes* : In these ropes, the strands are twisted into a rope in the opposite direction to that of the wires in the strands.

(ii) *Lang lay ropes* : In these ropes, the direction of twist of the wires in the strand is the same as that of the strands in the rope.

5. *How are wire ropes designated ?*

Wire ropes are designated (or specified) by the number of strands and the number of wires in each strand.

6. *What do you understand by 6×19 construction in wire ropes ?*

A 6×19 wire rope means a rope is made from 6 strands with 19 wires in each strand.

7. *Give the applications of the following wire ropes : (a) 6×7 rope ; (b) 6×19 rope.*

(a) *6×7 rope* : Used as haulage and guy rope in mines, tramways and power transmission.

(b) *6×19 rope* : Used as hoisting ropes in mines, quarries, cranes, derricks, elevators, well drilling, etc.

8. *List out the various stresses induced in the wire ropes.*

- ✓ Direct stress due to the weight of the load to be lifted and weight of the rope,
- ✓ Bending stress when the rope passes over the sheave,
- ✓ Stress due to acceleration, and
- ✓ Stress during starting stopping.

9. Ropes fail mainly by _____ and _____.

[Ans : fatigue ; wear]

10. "While designing a wire rope drive, always larger sheave diameter is preferred." Justify the statement.

We know that the bending stress induced in the wire rope,

$$\sigma_b = E_r \times \frac{d_w}{D}$$

where d_w = Wire diameter, and

D = Diameter of the sheave.

So it is clear that the bending stress induced in the rope is inversely proportional to the diameter of the sheave. Therefore the sheave diameter should be fairly large in order to reduce the bending stress in the rope when they bend around the sheaves.

CHAPTER – 4 : CHAIN DRIVES

1. When do you prefer a chain drive to a belt or rope drive ?

Chain drives are preferred for velocity ratio less than 10, chain velocities upto 25 m/s, and for power ratings upto 125 kW.

2. The limiting speed of a chain drive is _____.

[Ans : 25 m/s]

3. Give any three applications of chain drives.

Chain drives are widely used in transportation industry, agricultural machinery, metal and wood working machines.

4. What are the different types of chains ?

1. Link (or welded load) chains,
2. Transmission (or roller) chains, and
3. Silent (or inverted tooth) chains.

5. What are the applications of link (or hoisting) chains ?

Link (or hoisting) chains are widely used

- ✓ in low capacity machines such as hoists, winches and hand operated cranes as the main lifting appliances, and
- ✓ as slings for suspending the load from hook or other device.

6. How can you specify a link chain ?

A link chain is specified by the pitch, outside width, and diameter of the chain bar.

7. Distinguish short link and long link chains.

(i) **Short link chains** : If pitch $\leq 3 \times$ diameter of the chain bar, then the chains are known as short link chains.

(ii) **Long link chains** : If pitch $< 3 \times$ diameter of the chain bar, then the chains are known as long link chains.

8. Depending on the manufacturing accuracy, the link chains are classified as _____ and _____.
[Ans : Pitched ; Calibrated]

9. How does a hoisting chain differ from a roller chain ?

- ✓ Hoisting chains, also known as link chains, are used to suspend and / or lift the loads in hoisting machines.
- ✓ Roller chains, also known as transmission chains, are used for transmitting power between parallel shafts using sprockets.

10. A roller chain is specified by _____, _____, and _____.

[Ans : Pitch, width; diameter of roller]

11. What is chordal action in chain drives ?

When chain passes over a sprocket, it moves as a series of chords instead of a continuous arc as in the case of a belt drive. It results in varying speed of the chain drive. This phenomenon is known as chordal action.

12. What is the effect of chordal action in chain drives ? How can you reduce that effect ?

- ✓ Chordal action results in a pulsating and jerk motion of a chain.
- ✓ In order to reduce the variation in chain speed, the number of teeth on the sprocket should be increased.

13. In chain drives, the sprocket has odd number of teeth and the chain has even number of links. Why ?

Reason : To facilitate more uniform wear, i.e., the wear will be evenly distributed and thus total wear will be lower.

14. What are the materials used for making chains ?

- ✓ Link plates are made of medium-carbon or alloy steels such as C 45, C 50 and 40 Cr 1.
- ✓ Pins, bushings and rollers are made of carburising steels such as C₁₅, C 20, 30 Ni 4 Cr 1 and 15 Ni 2 Cr 1 Mo 15.

15. What is an offset link in a roller chain ?

When the chain has odd number of links, an additional link, called 'offset' link, is provided. But the offset link is weaker than the main links. That's why it is preferred to have even number of links.

16. What is a silent chain ? In what situations, silent chains are preferred ?

- ✓ Inverted tooth chains are called silent chains because of their relatively quiet operation.
- ✓ Silent drives are preferred for high-power, high-speed, and smooth operation.

17. What are the possible ways by which a chain drive may fail ?

The four basic modes of chain failure are :

(i) Near ; (ii) Fatigue ; (iii) Impact ; and (iv) Galling.

18. What is 'back sliding' in chain drives ?

The wear of the chain results in the elongation of the chain. In other words, the pitch length is increased. This makes the chain 'to ride out' on the sprocket teeth, resulting in a faulty engagement. This is known as 'back sliding' of chain.

19. Roller chains are designed to fail not in tension but by wear. Explain.

The chain links may not fail by tensile loading. But the rollers and pins mostly will fail by wear. Therefore roller chains are designed based on wear.

20. What you mean by galling of roller chains ?

Galling is a stick-slip phenomenon between the pin and the bushing. When the load is heavy and the speed is high, the high spots (*i.e.*, joints) of the contacting surfaces are welded together. This phenomenon of welding is called as galling of roller chains.

CHAPTER – 5 : SPUR GEARS

1. What are the advantages of toothed gears over the other types of transmission systems ?

Advantages of toothed gears are :

- ✓ Since there is no slip, so exact velocity ratio is obtained.
- ✓ It is capable of transmitting larger power.
- ✓ It is more efficiency and effective means of power transmission.

2. Medium velocity gears have a peripheral velocity range of _____ m/s.

[Ans : 3 to 15 m/s]

3. The size of the gears in metric system are usually specified by their _____.

[Ans : Module]

4. Back lash for spur gears depends on which two factors.

1. Module ; and 2. Pitch line velocity.

5. Define transmission ratio with reference to spur gears ?

It is the ratio of speed of driving gear to the speed of the driven gear.

6. Define module.

It is the ratio of the pitch circle diameter to the number of teeth.

7. In a pair of spur gears, the module is 6 mm. Determine the circular pitch and the diametral pitch.

(i) Circular pitch, $p_c = \pi \times m = \pi \times 6 = 18.85 \text{ mm}$ Ans. \rightarrow

(ii) Diametral pitch, $p_d = \frac{\pi}{p_c} = \frac{1}{m} = \frac{1}{6} = 0.166 \text{ mm}$ Ans. \rightarrow

8. State the conditions of correct gearing (or) state the law of gearing.

The law of gearing states that for obtaining a constant velocity ratio, at any instant of teeth the common normal at each of contact should always pass through a pitch point, situated on the line joining the centres of rotation of the pair of mating gears.

9. 'AGMA' stands for what ?

The American Gear Manufacturers Association.

10. If the centre distance of the mating gears having involute teeth is increased then the pressure angle is _____.

[Ans : increased ; because centre distance is inversely proportional to the cosine of pressure angle.]

11. What are the common forms of gear tooth profile ?

1. Involute tooth profile, and 2. Cycloidal tooth profile.

12. What are the standard interchangeable tooth profiles ?

- (i) $14 \frac{1}{2}^\circ$ composite system,
- (ii) $14 \frac{1}{2}^\circ$ full depth involute system ;
- (iii) 20° full depth involute system, and
- (iv) 20° stub involute system.

13. The best gear system to resist wear is _____ full depth. [Ans : 20° involute]

14. The commonly used gear tooth profile is _____. [Ans : 20° involute system]

15. _____ system has a strong tooth to take heavy loads.

[Ans : 20° stub involute system]

16. Define pitch circle with reference to spur gears.

Pitch circle is an imaginary circle which by pure rolling action, would give the same motion as the actual gear.

17. What are the materials used for gear manufacturing ?

- 1. Metallic gears : Steel, cast iron, and bronze.
- 2. Non-metallic gears : Wood, rowhide, compressed paper and synthetic resins.

18. When do you use non-metallic gears ?

Non-metallic gears are wherever noiseless operation is required. They are cheaper in cost and provide damping for shock and vibration.

19. What are the non-metallics used as gears ?

Wood, rawhide, compressed paper and synthetic resins like nylon.

20. Why is pinion made harder than gear ?

Because the teeth of pinion undergo more number of cycles than those of gear and hence quicker wear.

21. List out the various methods of manufacturing a gear.

1. Gear milling.
2. Gear generating : (i) Gear hobbing ; (ii) Gear shaping.
3. Gear molding : (i) Injection molding; (ii) Die casting; (iii) Investment casting.

22. What are the main types of gear tooth failure ?

1. Tooth breakage (due to static and dynamic loads).
2. Tooth wear (or surface deterioration) : (a) Abrasion ; (b) Pitting ; and (c) Scoring or seizure.

23. What are the assumptions made in deriving Lewis equation ?

1. The effect of radial component, which induces compressive stresses, is negligible.
2. The tangential component is uniformly distributed across the full face width.
3. The tangential force is applied to the tip of a single tooth.
4. Stress concentration in the tooth fillet is negligible.

24. The Lewis beam strength equation for spur gears is _____.

$$[Ans : F_s = \pi \times m \times b \quad [\sigma_b] \times y]$$

25. What is Lewis (or tooth) form factor ?

The Lewis equation is given by, $F_s = \pi \times m \times b \times [\sigma_b] \times \left[\frac{t^2}{6 \times h \times p_c} \right]$

where $\left[\frac{t^2}{6 \times h \times p_c} \right] = y$, known as Lewis form factor.

Lewis form factor is a dimensionless quantity. Since the dimensions t , h and p_c are increased proportionately when the gear is enlarged, the form factor value is always constant.

26. Why is a gear tooth subjected to dynamic loading ?

In a gear tooth, dynamic loads are due to the following reasons :

- ✓ Inaccuracies of tooth spacing,
 - ✓ Elasticity of parts,
 - ✓ Deflection of teeth under load,
 - ✓ Irregularities in tooth profiles,
 - ✓ Misalignment between bearings,
 - ✓ Dynamic unbalance of rotating masses.
27. Write the Buckingham's equation for dynamic load and expression for limiting wear load.

✓ Dynamic load, $F_d = F_t + \frac{21 v (b \cdot c + F_t)}{21 v + \sqrt{b \cdot c + F_t}}$

✓ Limiting wear load, $F_w = d_1 \times b \times Q \times K_w$

28. When both the pinion and the gear are made of the same material, then _____ should be designed. [Ans : pinion]

29. Why are the load correction factor and dynamic load factor are considered in gear design ?

- ✓ Load correction factor is considered to account for uneven distribution of tooth load along the face width of the tooth,
- ✓ Dynamic load factor is considered to account for profile and circular pitch errors, and velocity of operation.

30. What are the conditions required for interchangeability in tooth gears ?

Pressure angle and module should be same.

31. What are the effects of increasing and decreasing the pressure angle in gear design ?

- ✓ Increasing the pressure angle will increase the beam and surface strengths of tooth. But gear becomes noisy.
- ✓ Decreasing the pressure angle will increase the minimum number of teeth required on the pinion to avoid interference / undercutting.

32. The difference between the tooth space and the tooth thickness measured along the pitch circle is _____. [Ans : Back lash]

CHAPTER – 6 : HELICAL GEARS

1. Who do you prefer helical gears than spur gears ?

- ✓ Helical gears produce less noise than spur gears.
- ✓ Helical gears have a greater load capacity than equivalent spur gears.

2. Where do we use helical gears ?

Helical gears are commonly used in automobiles, turbines, and high speed applications.

3. What is the major disadvantage of single helical gear ? How can you overcome that difficulty ?

- ✓ Single helical gears are subjected to axial thrust loads.
- ✓ This axial thrust loads can be eliminated by using double helical (i.e., herringbone) gears.

4. **In helical gears, the right hand helixes on one gear will mesh _____ helixes on the other gear.** [Ans : Left hand]

5. **What hands of helix are used in parallel helical gears ?**

In parallel helical gears, opposite hands of helix are used. i.e., a right hand pinion meshes with a left hand gear and vice versa.

6. **Define axial pitch of a helical gear.**

The distance between corresponding points on adjacent teeth measured in the plane parallel to the shaft axis is known as axial pitch.

7. **The helix angle for single helical gears ranges from _____.** [Ans : 15° to 25°]

8. **What helix angle is adopted for a double helical gear ?**

45°

9. **What is virtual (or formative) number of teeth in helical gears ?**

The number of teeth on the virtual spur gear in the normal plane is known as virtual number of teeth (z_{eq}).

$$z_{eq} = \frac{z}{\cos^3 \beta}$$


where z = Actual number of teeth on a helical gear, and

β = Helix angle.

10. **A pair of helical gears consists of a 20 teeth pinion meshing with a 70 teeth gear. The normal module is 3 mm. Find the required value of the helix angle if the centre distance is exactly 150 mm.**

☺ **Solution :** Centre distance, $a = \left(\frac{m_n}{\cos \beta} \right) \times \left(\frac{z_1 + z_2}{2} \right)$

or $150 = \left(\frac{3}{\cos \beta} \right) \times \left(\frac{20 + 70}{2} \right)$

or Helix angle, $\beta = 25.84^\circ$ Ans. 

11. **What are the components of resultant forces acting on a gear tooth of a helical gear ?**

(i) Tangential component : $F_t = \frac{2 \times M_t}{d}$

(ii) Radial component : $F_r = F_t \times \left[\frac{\tan \alpha_n}{\cos \beta} \right]$

(iii) Axial or thrust force component : $F_a = F_t \times \tan \beta$

12. Write the expressions for beam strength, dynamic load, and limiting wear load for helical gears.

✓ Beam strength : $F_s = \pi \times m_n \times b \times [\sigma_b] \times y'$

✓ Dynamic load : $F_d = F_t + \frac{21 v (cb \cdot \cos^2 \beta + F_t) \cos \beta}{21 v + \sqrt{cb \cdot \cos^2 \beta + F_t}}$

✓ Wear load : $F_w = \frac{d_1 \times b \times Q \times K_w}{\cos^2 \beta}$

13. Differentiate double helical and herringbone gears.

✓ When there is groove in between the gears, then the gears are specifically known as **double helical gears**.

✓ When there is no groove in between the gears, then the gears is known as **herringbone gears**.

14. What are spiral (or skew) gears ? What hands of helix are used ?

✓ A pair of crossed-helical gears are known as spiral gears.

✓ In most applications, the spiral gears have the same hand.

15. Where do we use skew (or spiral) gears ?

Skew gears are used to connect and transmit motion between two non-parallel and non-intersecting shafts.

16. Why is the crossed helical gear drive mostly not used for power transmission ?

As the contact between the mating teeth of crossed helical gears is always a point, these gears are suitable only for transmitting a small amount of power. That's why mostly these gears are not used for power transmission.

17. What is the condition and expression for maximum efficiency in spiral gears ?

(i) Condition for maximum efficiency : Spiral angle, $\beta = \frac{\theta + \phi}{2}$

(ii) Maximum efficiency : $\eta_{\max} = \frac{\cos(\theta + \phi) + 1}{\cos(\theta - \phi) + 1}$

where θ = shaft angle, and ϕ = angle of friction.

CHAPTER – 7 : BEVEL GEARS

1. Under what situation, bevel gears are used ?

Bevel gears are used to transmit power between two intersecting shafts.

2. Differentiate a straight bevel gear and a spiral bevel gear.

When teeth formed on the cones are straight, the gears are known as **straight bevel** and when inclined, they are known as **spiral or helical bevel**.

3. **What are the advantages of spiral bevel gears over straight bevel gears ?**

Spiral bevel gears are smoother in action and quieter than straight bevel gears.

4. **What is zerol bevel gear ?**

Spiral bevel gear with curved teeth but with a zero degree spiral angle is known as *zerol* bevel gear.

5. _____ gears are used in automobile differential unit.

[Ans : Hypoid]

6. **What is a crown gear ?**

A bevel gear having a pitch angle of 90° and a plane for its pitch surface is known as a crown gear.

7. **What is the difference between an angular gear and a miter gear ?**

✓ When the bevel gears connect two shafts whose axes intersect at an angle other than a right angle, then they are known as *angular bevel gears*.

✓ When equal bevel gears (having equal teeth and equal pitch angles) connect two shafts whose axes intersect at right angle, then they are known as *miter gears*.

8. **Equal bevel gears when they connect two shafts at right angles are known as _____.**

[Ans : miter gears]

9. **What is meant by pitch angle in bevel gears ? Explain how the pitch angle of a bevel gear determines whether the gear is an external or internal bevel gear.**

✓ *Pitch angle* (or semi-cone angle) is the angle made by the pitch line of a gear with the gear axis.

✓ If sum of pitch angles is less than 90° , then those bevel gears are *external bevel gears*. Those gears having sum of pitch angles more than 90° , they are *internal bevel gears*.

10. **For bevel gears, define 'back cone distance.'**

Back cone distance is the length of the back cone. Back cone is an imaginary cone, perpendicular to the pitch cone at the end of the tooth.

11. **What are the forces acting on a bevel gear ?**

1. Tangential force,

2. Axial force, and

3. Radial force.

12. **If the axial force component on the gear is 625 N, then the radial component on the pinion is _____.**

[Ans : 625 N; but in opposite direction]

13. **If the radial force component on the gear is 1200 N, then the axial component on the pinion is _____.**

[Ans : 1200 N; but in opposite direction]

14. Write the expressions for beam strength, dynamic load, and limiting wear load for bevel gears.

✓ Beam strength :
$$F_s = \pi \times m_t \times b \times [\sigma_b] \times y' \times \left(\frac{R - b}{R} \right)$$

✓ Dynamic load :
$$F_d = F_t + \frac{21 v (bc + F_t)}{21 v + \sqrt{bc + F_t}}$$

✓ Wear load :
$$F_w = \frac{0.75 \times d_1 \times b \times Q' \times K_w}{\cos \delta_1}$$

CHAPTER – 8 : WORM GEARS

1. Under what situation, worm gears are used ?

The worm gears are used to transmit power between two non-intersecting, non-parallel shafts, and for high speed ratios as high as 300 : 1.

2. Where do we use worm gears ?

Worm gears are used as a speed reducer in materials handling equipment, machine tools and automobiles.

3. What is irreversibility in worm gears ?

The worm gear drives are irreversible. It means that the motion cannot be transmitted from worm wheel to the worm. This property of irreversible is advantageous in load hoisting applications like cranes and lifts.

4. What are single-enveloping and double-enveloping worm drives ?

- ✓ If the worm addendum forms a cylindrical surface, and if the worm-gear tooth are curved, then the drive is called **single-enveloping**.
- ✓ If the worm addendum has an hourglass form, and if the worm gear tooth are also curved, then the drive is called **double-enveloping**.

5. How can you specify a pair of worm gears ?

A pair of worm gears are specified as : $(z_1 / z_2 / q / m_x)$

- where
- z_1 = Number of starts on the worm,
 - z_2 = Number of teeth on the worm wheel,
 - q = Diameter factor = d_1/m_x , and
 - m_x = Axial module.

6. Define normal pitch of a worm gear ?

It is the distance measured along the normal to the threads between two corresponding points on two adjacent threads of the worm.

7. For worm gear, give the technical relationship between the normal lead (L_N), lead (L) and lead angle (γ).

$$L_N = L \times \cos \gamma$$

8. A pair of worm gears is designated as 2 / 54 / 10 / 5. Find the gear ratio.

☺ Solution : (2 / 54 / 10 / 5) : ($z_1 / z_2 / q / m_x$)

$$\therefore \text{Gear ratio, } i = \frac{z_2}{z_1} = \frac{54}{2} = 27 \text{ Ans. } \rightarrow$$

9. What is the velocity ratio range of worm gear drive ?

Velocity ratio ranges from 10 : 1 to 300 : 1.

10. The direction of rotation of the worm wheel can be found by considering the worm as _____ and worm wheel as _____. [Ans : screw ; nut]

11. Differentiate self-locking and overrunning worm drives.

✓ The drive is called self-locking, if $\mu \geq \cos \alpha \cdot \tan \gamma$.

✓ The drive is called overrunning, if $\mu < \cos \gamma \cdot \tan \gamma$.

12. _____ is the material widely used in the manufacture of worm wheel.

[Ans : Phosphor bronze]

13. Why phosphor bronze is widely used for worm gears ?

Phosphor bronze have high antifriction properties to resist seizure. Because in worm gear drive, the failure due to seizure is more.

14. List out the main types of failure in worm gear drive.

1. Seizure ; 2. Pitting and rupture.

15. In worm gear drive, only the wheel is designed. Why ?

Since always the strength of the worm is greater than the worm wheel, therefore only the worm wheel is designed.

16. For transmitting large power, worm reductions gears are not generally preferred. Why ?

In worm drive, meshing occurs with sliding action. Since sliding occurs, the amount of heat generation and power loss are quite high.

17. Why is dynamic loading rarely considered in worm gear drives ?

In worm gear drive, dynamic load is not so severe due to the sliding action between the worm and worm gear.

18. What are the various losses in the worm gear ?

✓ Losses due to friction is sliding (i.e., gearing loss), and

✓ Losses due to the churning and splashing of lubricating oil.

4. In worm gearing heat removal is an important design requirement. Why ?

Because the worm gear drives produce much heat. Unless proper heat removal is provided, the drive may eventually fail by seizure.

CHAPTER – 9 : GEAR BOX

1. What situations demand use of gear boxes ?

Gear boxes are required wherever the variable spindle speeds is necessary.

2. Write any two requirements of a speed gear box.

- ✓ Gear box should provide the designed series of spindle speeds.
- ✓ Gear box should transmit the required amount of power to the spindle.

3. Why G.P. series is selected for arranging the speeds in gear box ?

- ✓ The speed loss is minimum, if G.P. is used.
- ✓ The number of gears to be employed is minimum, if G.P. is used.
- ✓ G.P. provides a more even range of spindle speeds at each step.
- ✓ The layout is comparatively very compact, if G.P. is used.

4. List any two methods used for changing speeds in gear boxes.

1. Sliding mesh gear box, and
2. Constant mesh gear box.

5. What are preferred numbers ?

Preferred numbers are the conventionally rounded off values derived from geometric series. There are five basic series, denoted as R 5, R 10, R 20, R 40 and R 80 series.

6. What is step ratio ? (or) Define progression ratio.

When the spindle speeds are arranged in geometric progression, then the ratio between the two adjacent speeds is known as step ratio or progression ratio.

7. What is kinematic arrangement as applied to gear boxes ?

The kinematic layout shows the arrangement of gears in a gear box. It also provides informations like number of speeds available at each spindle and the number of stages used.

8. What does the ray-diagram of gear box indicates ?

The ray diagram is a graphical representation of the drive arrangement in general form. It serves to determine the specific values of all the transmission ratios and speeds of all the shafts in the drive.

9. State any three basic rules to be followed while designing a gear box.

1. The transmission ratio (i) in a gear box is limited by $\frac{1}{4} \leq i \leq 2$.

2. For stable operation, the speed ratio of any stage should not be greater than 8.
i.e., $N_{max} / N_{min} \leq 8$.

3. In all stages except in the first stage, $N_{max} \geq N_{input} > N_{min}$.

10. **What are the possible arrangements to achieve 12 speeds from a gear box ?**

The possible arrangements are :

(i) $3 \times 2 \times 2$ scheme ; (ii) $2 \times 3 \times 2$ scheme ; and (iii) $2 \times 2 \times 3$ scheme.

11. **List out the possible arrangements to achieve 16 speed gear box.**

(i) $4 \times 2 \times 2$ scheme ; (ii) $2 \times 4 \times 2$ scheme ; and (iii) $2 \times 2 \times 4$ scheme.

12. **What is a speed reducer ?**

Speed reducer is a gear mechanism with a constant speed ratio, to reduce the angular speed of output shaft as compared with that of input shaft.

CHAPTER – 10 : CLUTCHES

1. **What is the function of a clutch ?**

The clutch is a mechanical device which is used to connect or disconnect the source of power at the operator's will.

2. **Give examples for axial and radial friction clutches.**

✓ Axial friction clutches : Disc and cone clutches.

✓ Radial friction clutches : Centrifugal, internal expanding rim and external contracting rim clutches.

3. **What are the properties required of the material used as a friction surface ?**

The properties required of the friction materials are :

✓ A high and uniform coefficient of friction.

✓ Good resiliency.

✓ The ability to withstand high temperatures, together with good heat conductivity.

✓ High resistance to wear, scoring, and galling.

4. **Name few commonly used friction materials.**

Wood, cork, leather, asbestos based friction materials, and powdered metal friction materials.

5. **Clutches are usually designed on the basis of uniform wear. Why ?**

In clutches, the value of normal pressure, axial load for the given clutch is limited by the rate of wear that can be tolerated in the brake linings. Moreover, the assumption of uniform wear rate gives a lower calculated clutch capacity than the assumption of uniform pressure. Hence clutches are usually designed on the basis of uniform wear.

6. **Distinguish between dry and wet operation of clutches.**

- ✓ When a clutch operates in the absence of a lubricant, then that clutch is known as dry clutch. In dry clutch the torque capacity is high but the heat dissipating capacity is low.
- ✓ When a clutch operates 'wet' (i.e., with lubrication), then torque capacity is low but the heat dissipating capacity is high.

7. **Why a service factor is used for calculating the design capacity of a clutch ?**

In order to start a load from rest and accelerate it, a clutch should have torque capacity substantially greater than the nominal torque requirement so that the load can be accelerated without excessive slip. So service factor is used to account for driver and driven source variation and frequency of operation.

8. **In cone clutches semi-cone angle should be greater than 12° . Why ?**

We know that the torque capacity is inversely proportional to $\sin \alpha$. The value of α should be as small as possible. But when ' α ' is less than the angle of static friction (ϕ), the clutch has a tendency to grab, resulting in self-engagement. The self-engagement is not desirable because the clutch should engage or disengage only at the operator's will. To avoid self-engagement and to facilitate disengagement,

$$\alpha > \text{Angle of static friction.}$$

$$\alpha > \tan^{-1}(\mu)$$

Taking the coefficient of friction as 0.2, we get

$$\alpha > \tan^{-1}(0.2) \text{ or } \alpha > 11.3^\circ$$

Therefore, the semi-cone angle should be greater than 12° .

9. **What is the axial force required at the engagement and disengagement of cone clutch ?**

$$W = W_n (1 + \mu \cot \alpha)$$

10. **What is the difference between cone and centrifugal clutches ?**

Cone clutch works on the principle of friction alone. But centrifugal clutch uses principle of centrifugal force in addition with it.

11. **Compare disc clutches and cone clutches.**

- ✓ In disc clutches, friction lined flat plates are used.
- ✓ In cone clutches, friction lined frustum of cone is used.

12. **List out the elements of internal expanding rim clutches.**

1. The mating friction surface,
2. The means of transmitting the torque, and
3. The actuating mechanism.

13. *Why heat dissipation is necessary in clutches ?*

When clutch engages, most of the work done (against friction forces opposing the motion) will be liberated as heat at the interface. Consequently the temperature of the rubbing surface will increase. This increased temperature may destroy the clutch. So heat dissipation is necessary in clutches.

14. Give the relation to find temperature rise in clutches.

$$\text{Temperature rise, } \Delta T = \frac{E}{C \times m}$$

where E = Energy dissipated by the clutch,

C = Specific heat of clutch material, and

m = Mass of the clutch.

CHAPTER – 11 : BRAKES

1. *What is the function of a brake ?*

Brake is a mechanical device by means of which motion of a body is retarded for slowing down or to bring it to rest, by applying artificial frictional resistance.

2. *Differentiate a brake and a clutch.*

A clutch connects two moving members of a machine, whereas a brake connects a moving member to a stationary member.

3. *Differentiate a brake and a dynamometer.*

A dynamometer is a brake incorporating a device to measure the frictional resistance applied.

4. *Give examples for radial and axial brakes.*

Radial brakes : Band brakes, block brakes, and internal expanding rim.

Axial brakes : Cone brakes and disc brakes.

5. *What are the types of brake linings ?*

1. Organic linings, 2. Semi-metallic linings, and 3. Metallic linings.

6. *What is a self-locking brake ?*

When the frictional force is sufficient enough to apply the brake with no external force, then the brake is said to be self-locking brake.

7. *What you meant by self-energizing brake ?*

When the moment of applied force ($F \cdot l$) and the moment of the frictional force ($\mu \cdot R_N \cdot c$) are in the same direction, then frictional force helps in applying the brake. This type of brake is known as a self-energizing brake.

8. *Two blocks diametrically opposite to each other are used in a block brake. Why ?*

If only one block is used for braking, then there will be side thrust on the bearing of wheel shaft. This drawback can be removed by providing two blocks on the two sides of the drum diametrically opposite.

9. *Write an expression for the ratio between the tight and slack sides of a band and block brake.*

$$\frac{T_1}{T_2} = \left(\frac{1 + \mu \tan \theta}{1 - \mu \tan \theta} \right)^n$$

10. *The brake commonly used in automobiles is _____.*

[Ans : internal expanding brake]

11. *The brake widely used in motor cycles is _____.*

[Ans : disc brake]

12. *The brake used in railway coaches is _____.*

[Ans : block brake]