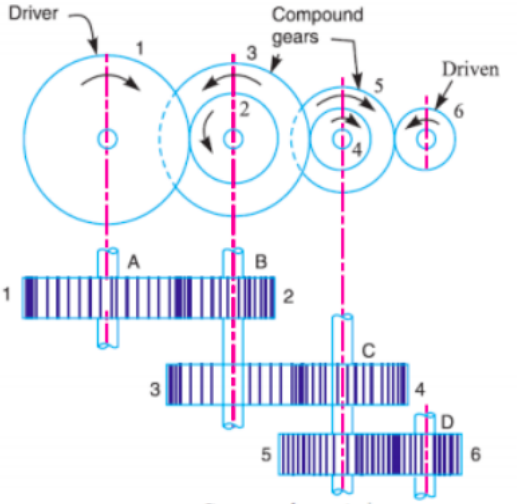
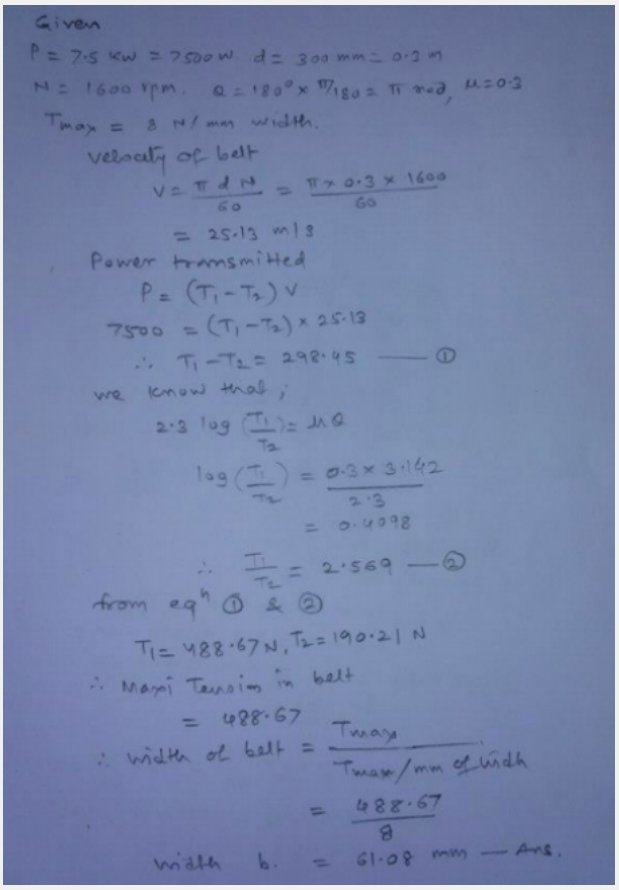
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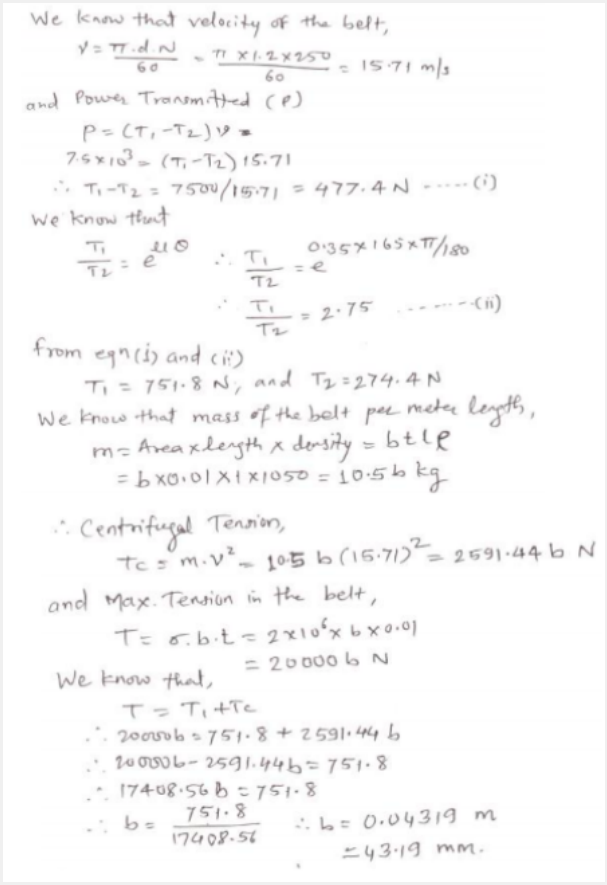
Examination: 2017 SUMMER

Que.No	Marks	
Q 1 i)	2	Question: **Write down the formula of length of belt for open belt drive and cross belt drive.** Answer: **Formula for length of open belt drive and cross belt drive:** Open belt drive: $L = 2C + \pi(D_2 + D_1)/2 + (D_2 - D_1)^2/4C$ Cross belt drive: $L = 2C + \pi(D_2 + D_1)/2 + (D_2 + D_1)^2/4C$ Where L=length. C=centre distance. D1 = pitch diameter of small pulley. D2 =pitch diameter of large pulley. ----------
Q 1 i)	2	Question: **List the methods to reduce the slip in belt and pulley.** Answer: **Methods to reduce the slip in belt and pulley:** 1. Vertical belt drive should be avoided. 2. In horizontal belt drive the upper side should be kept as loose side. ----------
Q 1 k)	2	Question: **Define law of gearing.** Answer: **Law of Gearing:** The law of gearing states that the angular velocity ratio of all gears of a meshed gear system must remain constant also the common normal at the point of contact must pass through the pitch point. ----------

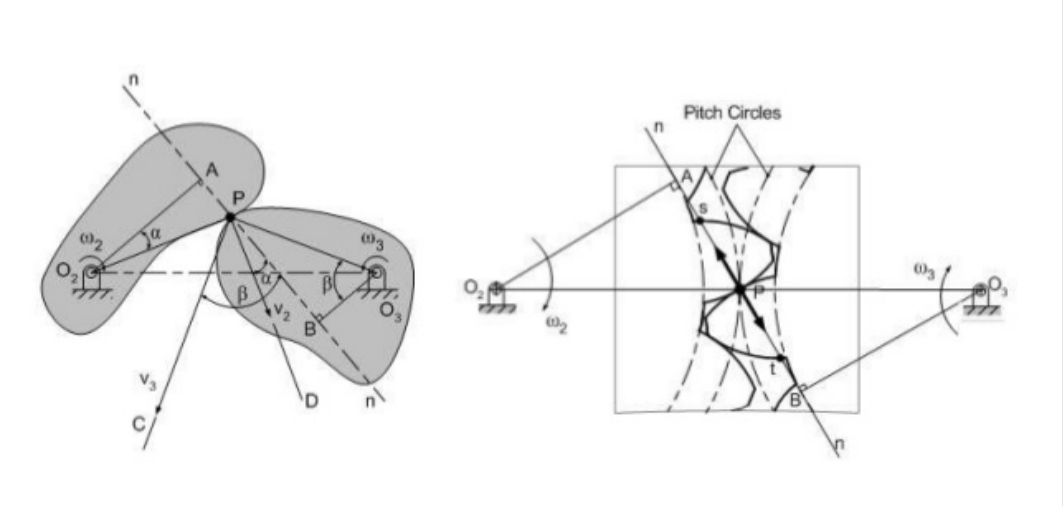
Que.No	Marks	
Q 2 d)	4	Question: **Explain condition for maximum power transmission.** Answer: **Condition for maximum power transmission** We know that power transmitted by a belt, $P = (T_1 - T_2)v$ ...(i) where T_1 = Tension in the tight side of the belt T_2 = Tension in the slack side of the belt and v = Velocity of the belt in m/s. We have also seen that the ratio of driving tensions is $\frac{T_1}{T_2} = e^{\mu.\theta}$ or $T_2 = \frac{T_1}{e^{\mu.\theta}}$ ...(ii) Substituting the value of T_2 in equation (i), $P = \left(T_1 - \frac{T_1}{e^{\mu.\theta}}\right)v = T_1\left(1 - \frac{1}{e^{\mu.\theta}}\right)v = T_1.v.C$ ...(iii) where $C = 1 - \frac{1}{e^{\mu.\theta}}$ We know that $T_1 = T - T_C$ where T = Maximum tension to which the belt can be subjected, and T_C = Centrifugal tension in newtons. Substituting the value of T_1 in equation (iii), $P = (T - T_C)v.C$ (Substituting $T_C = m.v^2$) $= (T - m.v^2)v.C = (T.v - m\,v^3)C$ For maximum power, differentiate the above expression with respect to v and equate to zero. i.e. $\frac{dP}{dv} = 0$ or $\frac{d}{dv}(T.v - mv^3)C = 0$ $\therefore \quad T - 3m.v^2 = 0$ or $T - 3T_C = 0$ or $T = 3T_C$ ...(iv) It shows that when the power transmitted is maximum, 1/3rd of the maximum tension is absorbed as centrifugal tension. ----------

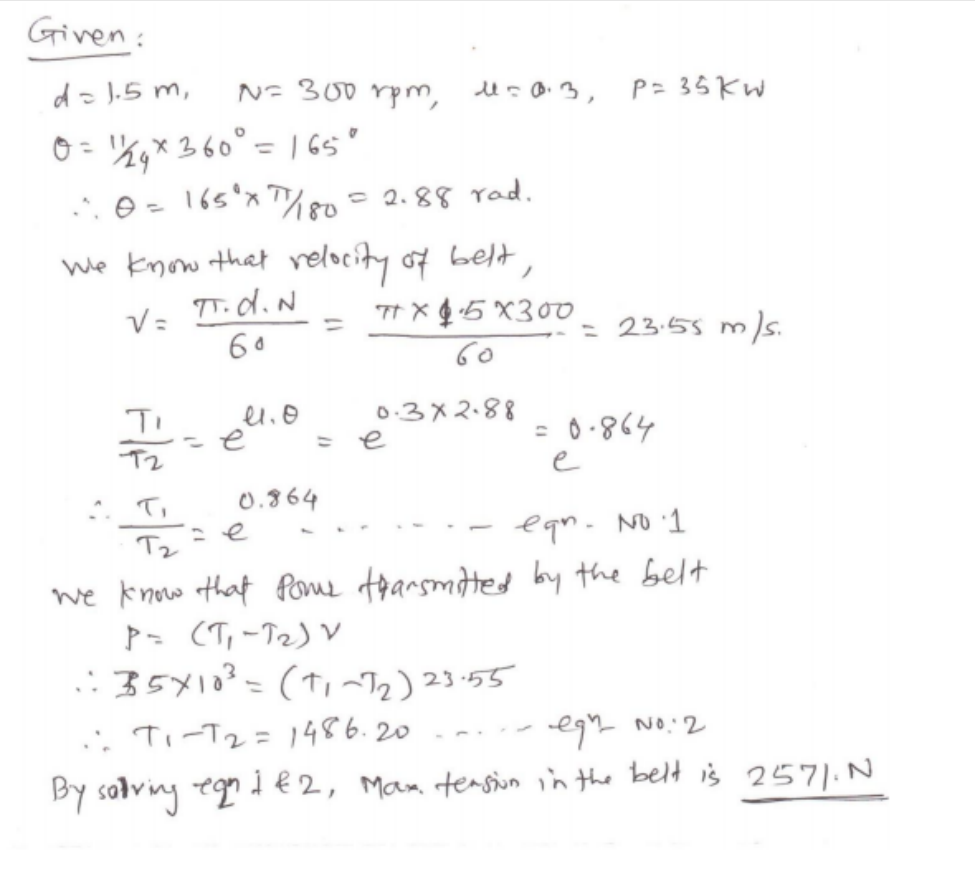
Que.No	Marks	
Q 2 e)	4	Question: **Explain the compound gear train with neat sketch and write down the velocity ratio's equation.** Answer: **Compound gear train** When there are more than one gear on a shaft, as shown in Fig. below, it is called a compound train of gear.  Compound gear train. In a compound train of gears, as shown in Fig., the gear 1 is the driving gear mounted on shaft A, gears 2 and 3 are compound gears which are mounted on shaft B. The gears 4 and 5 are also compound gears which are mounted on shaft C and the gear 6 is the driven gear mounted on shaft D. Let N1= Speed of driving gear 1, T1= Number of teeth on driving gear 1, N2,N3..., N6= Speed of respective gears in r.p.m., and T2,T3..., T6= Number of teeth on respective gears. Since gear 1 is in mesh with gear 2, therefore its speed ratio is $\frac{N_1}{N_2} = \frac{T_2}{T_1}$ ...(*i*) Similarly, for gears 3 and 4, speed ratio is $\frac{N_3}{N_4} = \frac{T_4}{T_3}$ ...(*ii*) and for gears 5 and 6, speed ratio is $\frac{N_5}{N_6} = \frac{T_6}{T_5}$ ...(*iii*) The speed ratio of compound gear train is obtained by multiplying the equations (*i*), (*ii*) and (*iii*), $\therefore \quad \frac{N_1}{N_2} \times \frac{N_3}{N_4} \times \frac{N_5}{N_6} = \frac{T_2}{T_1} \times \frac{T_4}{T_3} \times \frac{T_6}{T_5}$ $\frac{N_1}{N_6} = \frac{T_2 \times T_4 \times T_6}{T_1 \times T_3 \times T_5}$ Since gears 2 and 3 are mounted on one shaft B, therefore $N_2 = N_3$. Similarly gears 4 and 5 are mounted on shaft C, therefore $N_4 = N_5$. *i.e.* Speed ratio = $\frac{\text{Speed of the first driver}}{\text{Speed of the last driven or follower}}$ $= \frac{\text{Product of the number of teeth on the drivens}}{\text{Product of the number of teeth on the drivers}}$ and Train value = $\frac{\text{Speed of the last driven or follower}}{\text{Speed of the first driver}}$ $= \frac{\text{Product of the number of teeth on the drivers}}{\text{Product of the number of teeth on the drivens}}$ ----------

Que.No	Marks	
Q 3 d)	4	Question: **Find the width of the belt, necessary to transmit 7.5 kW to a pulley 300 mm diameter, if the pulley makes 1600 rpm and the co-efficient of friction between the belt and pulley is 0.3. Assume the angle of contact as 180o and the maximum tension in the belt is not to exceed 8 N/mm width.** Answer:  Given $P = 7.5\ kW = 7500\ W$ $d = 300\ mm = 0.3\ m$ $N = 1600\ rpm$. $\theta = 180^\circ \times \pi/180 = \pi\ rad$, $\mu = 0.3$ $T_{max} = 8\ N/mm$ width. Velocity of belt $V = \frac{\pi d N}{60} = \frac{\pi \times 0.3 \times 1600}{60}$ $= 25.13\ m/s$ Power transmitted $P = (T_1 - T_2) V$ $7500 = (T_1 - T_2) \times 25.13$ $\therefore T_1 - T_2 = 298.45$ —— ① we know that; $2.3 \log \left(\frac{T_1}{T_2}\right) = \mu\theta$ $\log \left(\frac{T_1}{T_2}\right) = \frac{0.3 \times 3.142}{2.3}$ $= 0.4098$ $\therefore \frac{T_1}{T_2} = 2.569$ —— ② from eqn ① & ② $T_1 = 488.67\ N$, $T_2 = 190.21\ N$ ∴ Max Tension in belt $= 488.67$ ∴ width of belt $= \frac{T_{max}}{T_{max}/mm\ of\ width}$ $= \frac{488.67}{8}$ width b. $= 61.08\ mm$ — Ans. ----------
Q 4 c)	4	Question: **What are the advantages of ‘V’ belt drive over flat belt drive ?** Answer: **Advantages of V-belt drive over flat belt drive :** 1. The V-belt drive gives compactness due to the small distance between the centres of pulleys. 2. The drive is positive, because the slip between the belt and the pulley groove is negligible. 3. Since the V-belts are made endless and there is no joint trouble, therefore the drive is smooth. 4. It provides longer life, 3 to 5 years. 5. It can be easily installed and removed. 6. The operation of the belt and pulley is quiet. 7. The belts have the ability to cushion the shock when machines are started. 8. The high velocity ratio (maximum 10) may be obtained. 9. The wedging action of the belt in the groove gives high value of limiting ratio of tensions. Therefore the power transmitted by V-belts is more than flat belts for the same coefficient of friction, arc of contact and allowable tension in the belts. 10. The V-belt may be operated in either direction with tight side of the belt at the top or bottom. The centre line may be horizontal, vertical or inclined. ----------

Que.No	Marks	
Q 5 c)	8	Question: **A leather belt is required to transmit 7.5 kW from a pulley 1.2 m in diameter running at 250 rpm. The angle of contact is 165o and the co-efficient of friction between the belt and the pulley is 0.35. If the safe working stress for the leather belt is 2 MPa, density of leather is 1050 kg/m3 and the thickness of belt is 10 mm, determine the width of belt, taking centrifugal tension into account.** Answer:  We know that velocity of the belt, $v = \frac{\pi . d . N}{60} = \frac{\pi \times 1.2 \times 250}{60} = 15.71$ m/s and Power Transmitted (P) $P = (T_1 - T_2) v$ $7.5 \times 10^3 = (T_1 - T_2) 15.71$ $\therefore T_1 - T_2 = 7500/15.71 = 477.4$ N ..... (i) We know that $\frac{T_1}{T_2} = e^{\mu \theta}$ $\therefore \frac{T_1}{T_2} = e^{0.35 \times 165 \times \pi/180}$ $\therefore \frac{T_1}{T_2} = 2.75$ ..... (ii) from eqn (i) and (ii) $T_1 = 751.8$ N, and $T_2 = 274.4$ N We know that mass of the belt per meter length, m = Area x length x density = $b t l \rho$ $= b \times 0.01 \times 1 \times 1050 = 10.5\, b$ kg $\therefore$ Centrifugal Tension, $T_c = m . v^2 = 10.5\, b\, (15.71)^2 = 2591.44\, b$ N and Max. Tension in the belt, $T = \sigma . b . t = 2 \times 10^6 \times b \times 0.01$ $= 20000\, b$ N We know that, $T = T_1 + T_c$ $\therefore 20000 b = 751.8 + 2591.44 b$ $\therefore 20000 b - 2591.44 b = 751.8$ $\therefore 17408.56 b = 751.8$ $\therefore b = \frac{751.8}{17408.56}$ $\therefore b = 0.04319$ m $= 43.19$ mm. ----------

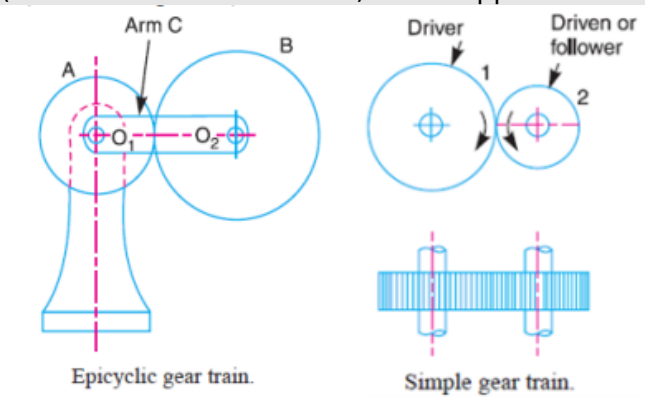
Examination: 2017 WINTER

Que.No	Marks	
Q 1a)(c)	2	Question: **State law of gearing.** Answer: Gearing law (Law of gearing) : *Gearing law states that, "The law of gearing states that the angular velocity ratio of all Gears of a meshed gear system must remain constant also the common normal at the point of contact must pass through the pitch point."*  Gearing law illustration As illustrated in above animation the common normal at the point of contact passes through the pitch point. Gearing law must be followed in order to two gears transmit motion form one to another. In order to have a constant angular velocity ratio for all positions of the wheels, it is must that the point P must be the fixed point (called pitch point) for the two wheels. In other words it can be said that , the common normal at the point of contact between a pair of teeth should always pass through the pitch point for proper working. This is the fundamental condition which must be satisfied while designing the profiles for the teeth of gear wheels, it is also known as the **law of gearing.** Gearing law explination with diagram ----------
Q 1a)(d)	2	Question: **State the types of chains & sprockets.** Answer: Types of Chains & Sprockets: The chains, on the basis of their use, are classified into the following three groups : 1. Hoisting and hauling (or crane) chains, 2. Conveyor (or tractive) chains, and 3. Power transmitting (or driving) chains. Sprockets: 1. Taper lock sprockets 2.Pilot bore sprocket 3.Platewheel sprocket ----------

Que.No	Marks	
Q 2 f)	4	Question: **A flat belt drive is required to transmit 35 kW from a pulley of 1.5 m effective diameter running at speed of 300 rpm. The angle of contact is spread over 11/24 of the circumference co-efficient of friction for the surface is 0.3. Determine the maximum tension in the belt.** Answer:  Given : $d = 1.5\ m, \quad N = 300\ rpm, \quad \mu = 0.3, \quad P = 35\ kW$ $\theta = \frac{11}{24} \times 360^\circ = 165^\circ$ $\therefore \theta = 165^\circ \times \pi/180 = 2.88\ rad.$ We know that velocity of belt, $V = \frac{\pi . d . N}{60} = \frac{\pi \times 1.5 \times 300}{60} = 23.55\ m/s.$ $\frac{T_1}{T_2} = e^{\mu . \theta} = e^{0.3 \times 2.88} = e^{0.864}$ $\therefore \frac{T_1}{T_2} = e^{0.864} \quad \ldots\ldots\ldots$ eqn. No 1 We know that Power transmitted by the belt $P = (T_1 - T_2) V$ $\therefore 35 \times 10^3 = (T_1 - T_2)\ 23.55$ $\therefore T_1 - T_2 = 1486.20 \quad \ldots\ldots$ eqn No: 2 By solving eqn 1 & 2, Max. tension in the belt is 2571. N ----------
Q 3 c)	4	Question: **Explain slip and creep phenomenon in belts.** Answer: **Define slip and creep in the belt drive Slip --- Slip is defined as insufficient frictional grip between pulley (driver/driven) and belt. Slip is the difference between the linear velocities of pulley (driver/driven) and belt. Creep -----** Uneven extensions and contractions of the belt when it passes from tight side to slack side. There is relative motion between belt and pulley surface, this phenomenon is called creep of belt. ----------

Que.No	Marks	
Q 4 a)	4	Question: **State advantages and disadvantages of chain drive over belt drive** Answer: Advantages of chain drive over belt drive (Any four) a) No slip takes place in chain drive as in belt drive there is slip. b) Occupy less space as compare to belt drive. c) High transmission efficiency. d) More power transmission than belts drive. e) Operated at adverse temperature and atmospheric conditions. f) Higher velocity ratio. g) Used for both long as well as short distances. Disadvantages of chain drive: 1. Manufacturing cost of chains is relatively high 2. The chain drive needs accurate mounting and careful maintenance 3. High velocity fluctuations especially when unduly stretched 4. Chain operations are noisy as compared to belts ----------

Que.No	Marks	
Q 5 c)	8	Question: **Two pulley, one 450 mm diameter and the other 200 mm diameter are on parallel shafts 1.95 m apart and are connected by a crossed belt. Find the length of the belt required and the angle of contact between the belt and each pulley. What power can be transmitted by the belt when the larger pulley rotates at 200 rpm, if the maximum permissible tension in the belt is 1 kN and the co-efficient of friction between the belt and pulley is 0.25 ?** Answer: **Solution.** Given : $d_1 = 450$ mm $= 0.45$ m or $r_1 = 0.225$ m ; $d_2 = 200$ mm $= 0.2$ m or $r_2 = 0.1$ m ; $x = 1.95$ m ; $N_1 = 200$ r.p.m. ; $T_1 = 1$ kN $= 1000$ N ; $\mu = 0.25$ We know that speed of the belt, $$v = \frac{\pi d_1 . N_1}{60} = \frac{\pi \times 0.45 \times 200}{60} = 4.714 \text{ m/s}$$ *Length of the belt* We know that length of the crossed belt, $$L = \pi (r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{x}$$ $$= \pi (0.225 + 0.1) + 2 \times 1.95 + \frac{(0.225 + 0.1)^2}{1.95} = 4.975 \text{m}$$ Ans. *Angle of contact between the belt and each pulley* Let θ = Angle of contact between the belt and each pulley. We know that for a crossed belt drive, $$\sin \alpha = \frac{r_1 + r_2}{x} = \frac{0.225 + 0.1}{1.95} = 0.1667 \text{ or } \alpha = 9.6^\circ$$ $$\therefore \quad \theta = 180^\circ + 2\alpha = 180^\circ + 2 \times 9.6^\circ = 199.2^\circ$$ $$= 199.2 \times \frac{\pi}{180} = 3.477 \text{ rad}$$ Ans. *Power transmitted* Let T_2 = Tension in the slack side of the belt. We know that $$2.3 \log \left(\frac{T_1}{T_2} \right) = \mu . \theta = 0.25 \times 3.477 = 0.8692$$ $$\log \left(\frac{T_1}{T_2} \right) = \frac{0.8692}{2.3} = 0.378 \text{ or } \frac{T_1}{T_2} = 2.387$$ ...(Taking antilog of 0.378) $$\therefore \quad T_2 = \frac{T_1}{2.387} = \frac{1000}{2.387} = 419 \text{ N}$$ We know that power transmitted, $$P = (T_1 - T_2) v = (1000 - 419)\, 4.714 = 2740 \text{ W} = 2.74 \text{ kW}$$ Ans. ----------

Que.No	Marks	
Q 6a)(i)	8	Question: **State types of gear train and explain any one.** Answer: i) Types of gear trains 1) Simple gear train 2) Compound gear train 2) Epicyclic gear train 4) Inverted gear train Simple gear train. When there is only one gear on each shaft, it is known as simple gear train. The gears are represented by their pitch circles. When the distance between the two shafts is small, the two gears are made to mesh with each other to transmit motion from one shaft to the other Epicyclic gear train: A simple epicyclic gear train is shown in Fig. where a gear A and the arm C have a common axis at O1about which they can rotate. The gear B meshes with gear A and has its axis on the arm at O2, about which the gear B can rotate. If the arm is fixed, the gear train is simple and gear A can drive gear B or vice- versa, but if gear A is fixed and the arm is rotated about the axis of gear A (i.e. O1), then the gear B is forced to rotate upon and around gear A. Such a motion is called epicyclic and the gear trains arranged in such a manner that one or more of their members move upon and around another member are known as epicyclic gear trains. Compound Gear Train When there are more than one gear on a shaft, it is called a compound train of gear. Whenever the distance between the driver and the driven or follower has to be bridged over by intermediate gears and at the same time a great (or much less) speed ratio is required, then the advantage of intermediate gears is intensified by providing compound gears on intermediate shafts Reverted Gear Train When the axes of the first gear (i.e. first driver) and the last gear (i.e. last driven or follower) are co-axial, then the gear train is known as reverted gear train. We see that gear 1 (i.e. first driver) drives the gear 2 (i.e. first driven or follower) in the opposite direction.  ----------

Examination: 2016 SUMMER

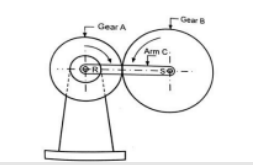
<table>
<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 1a)(iii)</td><td>2</td><td>Question:
How are drives classified?

Answer:
Classification of drives:
(i) Belt drives.
(ii) Chain drives.
(iii) Rope.
(iv) Gear drives.
---</td></tr>
<tr><td>Q 1a)(v)</td><td>2</td><td>Question:
Write any two disadvantages of chain drive.

Answer:
Disadvantages of chain drives:
1. Manufacturing cost of chains is relatively high.
2. The chain drive needs accurate mounting and careful maintenance.
3. High velocity fluctuations especially when unduly stretched.
4. Chain operations are noisy as compared to belts.
---</td></tr>
<tr><td>Q 1b)(iii)</td><td>4</td><td>Question:
Compare cross belt drive and open belt drive on the basis of: (i) Velocity ratio. (ii) Direction of driven pulley. (iii) Length of belt drives (iv) Application.

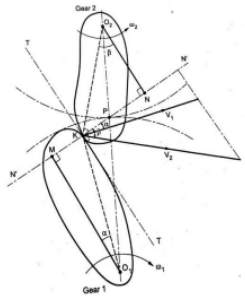
Answer:
Comparison between cross and open belt drive:
<table><tr><th>Sr. No.</th><th>Parameter</th><th>Cross belt drive</th><th>Open belt drive</th></tr><tr><td>01</td><td>Velocity ratio</td><td>High</td><td>Low</td></tr><tr><td>02</td><td>Direction of driven pulley</td><td>Same as driver pulley</td><td>Opposite to driven pulley</td></tr><tr><td>03</td><td>Length of belt drive</td><td>Long</td><td>Short</td></tr><tr><td>04</td><td>Application</td><td>Large amount of power to be transmitted</td><td>Less amount of power to be transmitted</td></tr></table>---</td></tr>
<tr><td>Q 2 f)</td><td>4</td><td>Question:
A shaft runs at 80 rpm & drives another shaft at 150 rpm through belt drive. The diameter of the driving pulley is 600 mm. Determine the diameter of the driven pulley in the following cases: (i) Taking belt thickness as 5 mm. (ii) Assuming for belt thickness 5 mm and total slip of 4%.

Answer:
Ans.: Given data; N1 = 80 rpm. N2 =150 rpm. D1= 600 mm. S = 4 % To find; D2 =?;
(i) Case I: Taking t = 5 mm. Velocity ratio, (V.R.) N2/N1 = (D1 + t)/ (D2 + t)
150/80 = (600 + 5)/ (D2 + 5)
Therefore, diameter of driven pulley D2 = 317.66 mm ~ 318mm
(ii) Case II: Assuming for belt thickness 5 mm and total slip of 4%. Velocity ratio, (V.R.) N2/N1 = {(D1 + t)/ (D2 + t)} × {1- (S/100)}
150/80 = {(600 + 5) / (D2 + 5)} × {1- (4/100)
Therefore, diameter of driven pulley D2 = 304.76 mm ~ 305 mm
---</td></tr>
<tr><td>Q 3 c)</td><td>4</td><td>Question:
Explain epicyclic gear train with neat sketch.

Answer:


In case of Epicyclic Gear train, the axis of shafts on which gears are mounted may have a relative motion between them, unlike other gear trains. This gives advantage that, very high or low velocity ratio can be obtained compared to simple and compound gear trains; in the small space. In above sketch, if gears A and B are rotating and arm RS is fixed, then it behaves like simple gear train. However, when Arm C rotates and gear A is fixed, then train becomes epicyclic. It is also known as planetary gear train. Applications- Differential gears of the automobiles, back gear of lathe, hoists, pulley blocks
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</table>

Que.No	Marks	
Q 5 a)	4	Question: **State and explain Law of Gearing.** Answer: ## Law of Gearing Law of gearing states that the common normal at the point of contact between a pair of teeth must always pass through the pitch point for all positions of mating gear. This law forms the basis for the gear profile design. This is a must condition for the two gears to perform properly. ### Law of gearing Proof Consider the portions of two gear teeth in mesh.o1 and o2 are centre points, Let K= point of contact TT = COmmon tangent at the point of contact K N'N' = common tangent at the pont of contact K O1m and O2N are perpendicular to common normal N'N'.



Consider the portions of two gear teeth in mesh. O_1 and O_2 are centre points.
Let K= point of contact
T T = Common tangent at point of contact K
N'N' = Common Normal at point of contact K
O_1M and O_2N are perpendicular to Common Normal N'N'.

V_1 and V_2 =Velocities at point K w. r. t. gear 1 and 2 respectively
If mating teeth to remain in contact while transmitting motion, components of velocities must be equal along N'N'.
So, $V_1 \cos \propto = V_2 \cos \beta$
$(\omega 1 \times O1K) \cos \propto = (\omega 2 \times O2K) \cos \beta$
From triangles O1MK and O2NK putting values of cos $\propto$ and COS β

$$\omega_1 \times O_1K \times \frac{O1M}{O1K} = \omega_2 \times O_2K \times \frac{O2N}{O2K}$$

$$\omega_1 \times O_1M = \omega_2 \times O_2N$$

$$\frac{\omega 1}{\omega 2} = \frac{O2N}{O1M} \quad \ldots\ldots\ldots\ldots(1)$$

Since O_1MP and O_2NP are similar triangles.

$$\frac{O2N}{O1M} = \frac{O2P}{O1P} \quad \ldots\ldots\ldots\ldots(2)$$

From equations (1) and(2) , we get

$$\frac{\omega 1}{\omega 2} = \frac{O2P}{O1P}$$

From this, it is proved that angular velocity ratio is inversely proportional to ratio of distance of fixed point 'P' ,which is pitch point. This gives constant angular velocity ratio.

In other words, the common normal at the point of contact between a pair of teeth must always pass through the pitch point for all positions of mating gears. This is the fundamental condition which must be satisfied while designing the profiles of teeth for gears. This is Law of Gearing or Condition of correct gearing.

Law of gearing animation
As shown in the diagram below the common normat at the point of contact between a pair of teeth must always pass through the pitch point for all positions of mating gears.
This is the fundamental condition which must be satisfied while designing the profiles of teeth for gears.

This law is must for a gearing pair to perform properly. The animation clearly demonstrates the blue line which traces the path of the point of contact.

Link to other topics of Theory of machines is given below.
- Unit-1-Fundamentals and type of mechanisms
- Unit-2-Velocity and Acceleration in Mechanisms
- Unit-3-Cams and Followers
- Unit-4-Belt,Chain and Gear Drives
- Unit-5-Brakes and Clutches
- Unit-6-Flywheel,Governor and Balancing
- Question Paper And Solution

Que.No	Marks	
Q 5 c)	8	Question: **Two parallel shafts, connected by a crossed belt, are provided with pulleys 480 mm and 640 mm in diameters. The distance between the centre lines of the shafts is 3 m. Find by how much the length of the belt should be changed if it is desired to alter the direction of rotation of the driven shaft.** Answer: $D_1 = 480mm = 0.48m \quad R_1 = 0.24m$ $D_2 = 640mm = 0.64m \quad R_2 = 0.32m$ $x = 3m$ Crossed belt= $L = \Pi(r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{1}$ ----------**1 mark** $L = \Pi(0.24 + 0.32) + 2(3) + \frac{(0.24 + 0.32)^2}{3}$ $L = 7.863mm$ ----------**2 marks** Now Rotation Alter(open belt) $L = \Pi(r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{1}$ ----------**1 mark** $L = \Pi(0.24 + 0.32) + 2(3) + \frac{(0.24 - 0.32)^2}{3}$ $L = 7.76mm$ ----------**2 marks** **Length of belt should be changed,** L=(Length of cross belt)-(length of open belt) =7.863-7.76 **L=0.103 mm** ----------**2 marks** ----------
Q 6a)(i)	4	Question: **Explain steep and creep phenomenon in belts.** Answer: **Slip of Belt:-** Ans:- When driver pulley rotates firm grip between its surface and the belt. This firm grip between pulley and belt is because of friction and known as frictional grip. If this frictional grip becomes insufficient to transmit the motion of pulley to belt. Then there will be. 1) Forward motion of driver pulley without carrying belt called as slip on driving side. 2) Some forward motion of belt without carrying driven pulley this is called as slip on driver side. The difference between linear speed of rim of pulley and belt on the pulley is known as slip of belt. The velocity ratio considering slip is given by:- **a) Neglecting Thickness of Belt and Considering Slip:-** $\frac{N_2}{N_1} = \frac{d_1}{d_2}\left[1 - \frac{5}{100}\right]$ **b) Considering Thickness:-** $\frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}\left[1 - \frac{5}{100}\right]$ **Creep of Belt:-** The belt moves from driving pulley is known as Tight side and belt moves from driving pulley to driver pulley as slack side. Tension on both i.e. on tight sides and slack side is not equal (T1> T2) . The belt material is elastic material which elongates more on Tight side than the slack side resulting in unequal stretching on both sides of drive. A certain portion of belt when passes from slack side to tight side extends and certain portion of belt when contracts, passes from tight side to slack side because of relative motion. The relative motion between belt and pulley surface due to unequal stretching of two sides of drives is known as creep. ----------

Examination: 2016 WINTER

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Q 1a)(iv)	2	Question: **Define slip and creep in case of belt drive.** Answer: **Slip** --- Slip is defined as insufficient frictional grip between pulley (driver/driven) and belt. Slip is the difference between the linear velocities of pulley (driver/driven) and belt. **Creep** ----- Uneven extensions and contractions of the belt when it passes from tight side to slack side. There is relative motion between belt and pulley surface, this phenomenon is called creep of belt. ---
Q 1a)(v)	2	Question: **Give four advantages of chain drive over belt drive.** Answer: **Advantages of chain drive over belt drive** a) No slip takes place in chain drive as in belt drive there is slip. b) Occupy less space as compare to belt drive. c) High transmission efficiency. d) More power transmission than belts drive. e) Operated at adverse temperature and atmospheric conditions. f) Higher velocity ratio. g) Used for both long as well as short distances ---
Q 1a)(vi)	2	Question: **State the effect of centrifugal tension on power transmission.** Answer: **Effect of centrifugal tension on power transmission:** As the belt passes over the pulley with high velocity, centrifugal force is produced on the belt, which tends to act on the belt. This force tries to move the belt away from the pulley. This force is given by, $T_C = m \times V^2$ There is no effect of centrifugal tension on power transmitted. ---

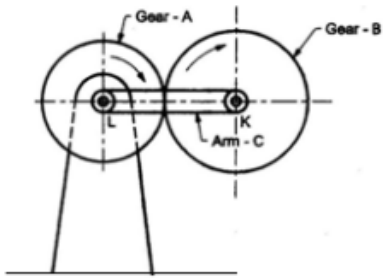
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Q 1b)(iii)	4	Question: **The central distance two shaft is 4m having two pulleys with diameter having 500mm and 700mm respectively find the length of belt required - (1) for open belt drive (2) for cross belt drive** Answer: Central distance between two shafts; C = 4 Meters; = 4000 mm. Smaller pulley diameter = d = 500 mm; Smaller pulley radius = r= 250 mm; Larger pulley diameter = d = 700 mm; lager pulley radius = r= 350 mm; Angle subtended by each tangent β **a) Length of open belt drive** Angle subtended by each tangent $\beta = \sin^{-1}(R-r/C) = \sin^{-1}((350-250)/4000)$ B = 0.025 radians $L_O = \pi(R+r)2x\,\beta\,(R-r) + 2\,C \times \cos\beta = 9.889$ m **$L_O = 9.889$ m** **b) Length of cross belt drive** Angle subtended by each tangent $\beta = \sin^{-1}(R+r/C) = \sin^{-1}((350+250)/4000)$ $\beta = 0.01575$ radians $L_C = \pi(R+r)2x\,\beta\,(R-r) + 2\,C \times \cos\beta = 9.903$ m **$L_C = 9.903$ m** ----------
Q 2 f)	4	Question: **A pulley is driven by the flat belt running at speed of 600m/min. and transmit 4 kW. The coefficient of friction between belt and pulley is 0.3 and angle of lap is 160°. Find maximum tension in the belt.** Answer: Flat belt speed = V = 600 m/min = 600/60 m/sec = 10 m/sec; Power transmitted = P = 4 kW ; Coefficient of friction =μ = 0.3; Angle of lap = θ =1600 Belt tension ratio = T1/ T2 = eμθ = e 0.3(160x π/180) = 2.31; T1/ T2 = 2.31; T1= T2 x 2.311----------(1) P = (T1 - T2) x V ; ----------(2) P = (T2 x 2.31- T2)x 10; Putting value of power P = 4 kW 4 x1000 = (T2 x 2.31 - T2)x 10; **T2 = 305.34 N** **T1 = 705.34N** ----------

<table>
<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 3 c)</td><td>4</td><td>Question:
Compare cross belt drive and open belt drive on the basis of - (i) Velocity ratio (ii) Direction of driven pulley (iii) Application (iv) Length of belt drive

Answer:
<table>
<tr><th>Sr. no.</th><th>Parameters</th><th>Cross belt drive</th><th>Open belt drive</th></tr>
<tr><td>1</td><td>Velocity ratio</td><td>High velocity ratio</td><td>Low velocity ratio</td></tr>
<tr><td>2</td><td>Direction of driven pulley</td><td>Rotated in same direction as the driving as the driving pulley</td><td>Rotated in the opposite direction to the driving pulley</td></tr>
<tr><td>3</td><td>Application</td><td>Sawmills, buck saws</td><td>Conveyors, electrical generator</td></tr>
<tr><td>4</td><td>Length of belt drive</td><td>$L=\Pi(r_1+r_2)+2C+\frac{(r_1-r_2)^2}{C}$</td><td>$L=\Pi(r_1+r_2)+2C+\frac{(r_1+r_2)^2}{C}$</td></tr>
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<tr><td>Q 3 f)</td><td>4</td><td>Question:
Explain with neat sketch working principle of epicyclic gear train.

Answer:
In single, Compound reveted gear trains the axis on which gears are mounted are fixed relative to each other. In case of epicyclic gear train the axis of shaft on which the gears are mounted may have relative motion between them.

Gear ‘A’ and arm ‘C’ rotate about fixed axis. The gear ‘B’ rotates about axis ‘S’ and also about arm ‘C’ which in turn revolves about fixed axis through ‘R’. The gear ‘A’ and ‘B’ are simple gear train when arm ‘C’ is fixed. ()



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<tr><td>Q 4 a)</td><td>4</td><td>Question:
Generally, the lower side is kept “Tight side” and upper side is kept as “Slack side” with the belt drives having small driving pulley and big driven pulley. Why ?

Answer:
Power transmission in belt drive depends on angle of lap and frictional grip between belt and pulley. As slack side is at upper side angle of lap and grip increases.
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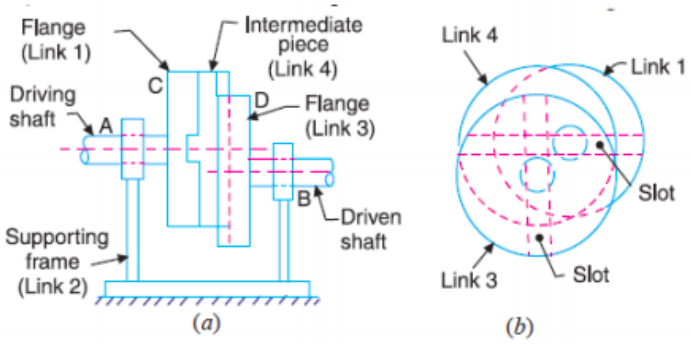
Examination: 2015 SUMMER

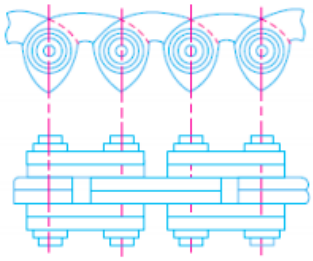
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<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 1a)(c)</td><td>2</td><td>Question:
Define angle of lap and slip in belt drive.

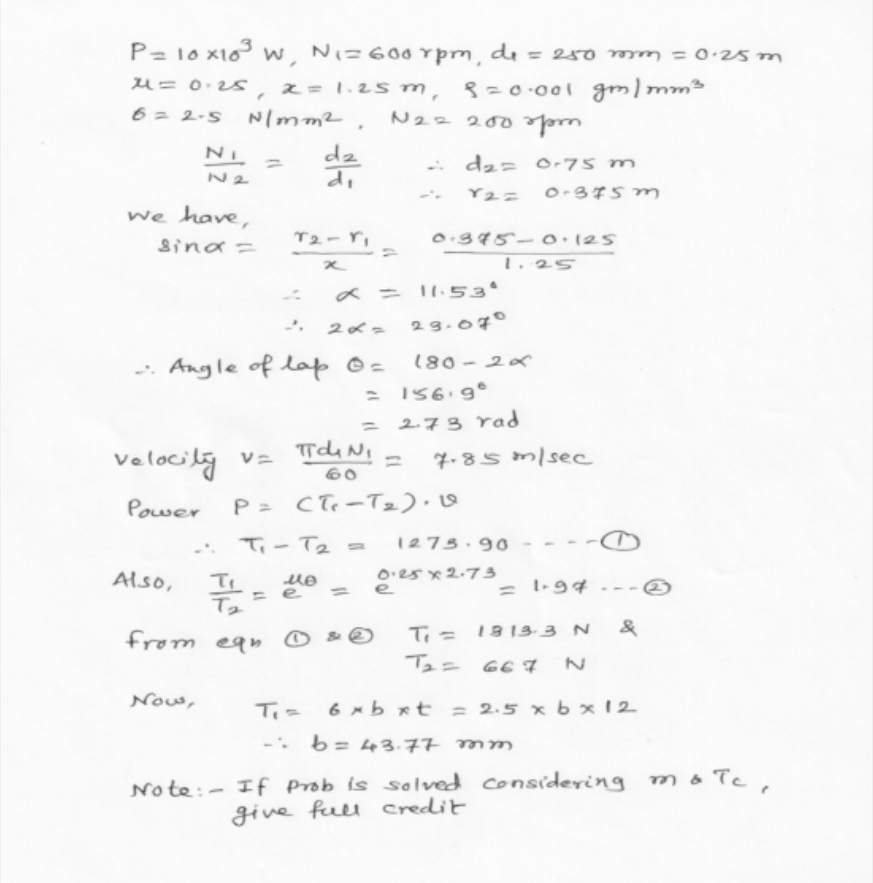
Answer:
Slip of belt : The motion of belts and shafts assuming a firm frictional grip between the belts and the shafts. But sometimes, the frictional grip becomes insufficient. This may cause some forward motion of the driver without carrying the belt with it. This may also cause some forward motion of the belt without carrying the driven pulley with it. This is called slip of the belt and is generally expressed as a percentage.
Angle of Lap : The angle of lap is defined as the angle subtended by the portion of the belt which is in contact at the pulley surface of the pulley.
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<tr><td>Q 1a)(d)</td><td>2</td><td>Question:
State four conditions under which the ‘V’ belt drive is selected.

Answer:
Conditions for ‘V’ Belt drive selection :
1. Great amount of Power to be transmitted,
2. Requirement of the high velocity ratio (maximum 10).
3. Small Centre distance between the shafts
4. Positive drive requirement
5. Compact Space
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<tr><td>Q 1b)(c)</td><td>4</td><td>Question:
Compare cross belt drive and open belt drive on the basis of (i) velocity ratio (ii) application (iii) direction of driven pulley (iv) length of belt drive

Answer:
Comparison between cross belt drive and open belt drive :
<table>
<tr><th>Sr. No.</th><th>Parameter</th><th>Cross belt drive</th><th>Open belt drive</th></tr>
<tr><td>1</td><td>Velocity ratio</td><td>High</td><td>Low</td></tr>
<tr><td>2</td><td>Application</td><td>Large amount of power to be transmitted</td><td>Less amount of power to be transmitted</td></tr>
<tr><td>3</td><td>Direction of driven pulley</td><td>Same as driver pulley</td><td>Opposite to driven pulley</td></tr>
<tr><td>4</td><td>Length of belt drive</td><td>Long</td><td>short</td></tr>
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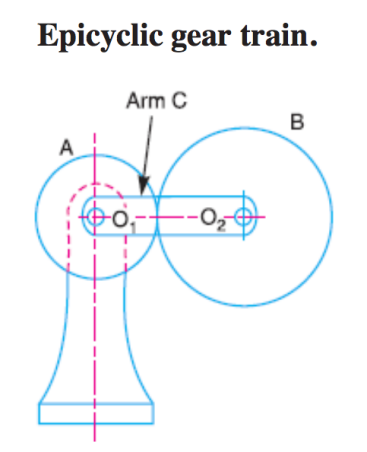
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Q 2 b)	4	Question: **Explain with neat sketch working principle of Oldham's coupling.** Answer: An Oldham's coupling is used for connecting two parallel shafts whose axes are at a small distance apart. The shafts are coupled in such a way that if one shaft rotates, the other shaft also rotates at the same speed. This inversion is obtained by fixing the link 2, as shown in Fig. The shafts to be connected have two flanges (link 1 and link 3) rigidly fastened at their ends by forging. The link 1 and link 3 form turning pairs with link 2. These flanges have diametrical slots cut in their inner faces, as shown in Fig. The intermediate piece (link 4) which is a circular disc, have two tongues (*i.e.* diametrical projections) $T1$ and $T2$ on each face at right angles to each other. The tongues on the link 4 closely fit into the slots in the two flanges (link 1 and link 3). The link 4 can slide or reciprocate in the slots in the flanges.  Oldham's coupling. When the driving shaft A is rotated, the flange C (link 1) causes the intermediate piece (link 4) to rotate at the same angle through which the flange has rotated, and it further rotates the flange D (link 3) at the same angle and thus the shaft B rotates. Hence links 1, 3 and 4 have the same angular velocity at every instant. A little consideration will show that there is a sliding motion between the link 4 and each of the other links 1 and 3. ----------
Q 2 f)	4	Question: **The central distance between two shaft is 4 m having two pulleys with diameter having 500 mm and 700 mm respectively. Find length of belt required (i) for open belt drive (ii) for cross belt drive** Answer: **f) Problem on belt drive (02 marks each length)** i) for open belt $L = \pi/2\,(d_1 + d_2) + 2x + (d_1 - d_2)^2 / 4x$ $= 9.8865$ m ii) for cross belt $L = \pi/2\,(d_1 + d_2) + 2x + (d_1 + d_2)^2 / 4x$ $= 9.974$ m ----------

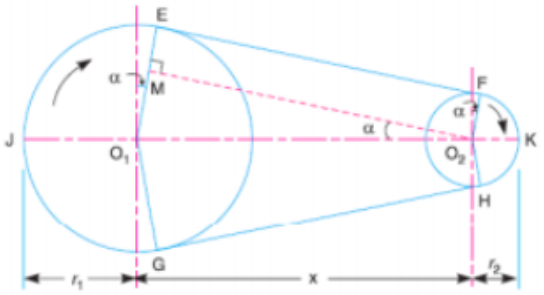
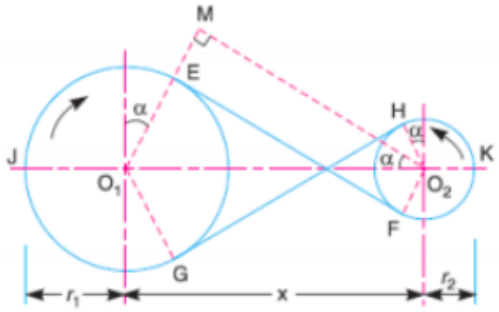
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Q 3 d)	4	Question: **State the type of power transmission chains. Describe any one with its sketch.** Answer: **Types of power transmission chains :** **i)** Block chain or bush chain drive **ii)** Bush roller chain **iii)** Inverted tooth or silent chain **Fig. shows** inverted tooth or silent chain. It is designed to eliminate the evil effects caused by stretching and to produce noiseless running. When the chain stretches and the pitch of the chain increases, the links ride on the teeth of the sprocket wheel at a slightly increased radius. This automatically corrects the small change in the pitch. There is no relative sliding between the teeth of the inverted tooth chain and the sprocket wheel teeth. When properly lubricated, this chain gives durable service and runs very smoothly and quietly.  Inverted tooth or silent chain. ----------
Q 4 a)	4	Question: **Explain the phenomenon of slip and creep in a belt drive. State its effect on velocity ratio.** Answer: **Slip of the belt:** A firm frictional grip between belt and shaft is essential. But sometimes it becomes insufficient. This may cause some forward motion of the belt without carrying the driven pulley with it. This called as slip of the belt. It is expressed as a percentage. **Effect on velocity ratio:** Result of belt slipping is to reduce the velocity ratio of the system. **Creep in belt drive :** When the belt passes from slack side to tight side, a certain portion of the belt extends and it contracts again when the belt passes from tight sight to slack side. Due to these changes in length, there is a relative motion between the belt and the pulley surfaces. This relative motion is called as creep. **Effect on velocity ratio:** The total effect of creep is to reduce slightly the speed of the driven pulley or follower. ----------

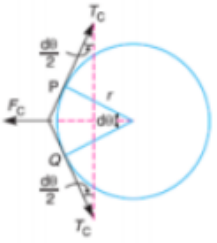
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Q 5 c)	8	Question: **A belt is required to transmit 10 kW from a motor running at 600 rpm. The belt is 12 mm thick and has a mass density 0.001 gm/mm3 . Safe stress in the belt is not to exceed 2.5 N/mm2 , diameter of the driving pulley is 250 mm whereas the speed of the driven pulley is 200 rpm. The two shafts are 1.25 m apart. The coefficient of friction is 0.25, determine (1) Angle of contact at driving pulley (2) The width of the belt** Answer:  $P = 10 \times 10^3$ W, $N_1 = 600$ rpm, $d_1 = 250$ mm $= 0.25$ m $\mu = 0.25$, $x = 1.25$ m, $\rho = 0.001$ gm/mm^3 $\sigma = 2.5$ N/mm^2, $N_2 = 200$ rpm $\frac{N_1}{N_2} = \frac{d_2}{d_1}$ $\therefore d_2 = 0.75$ m $\therefore r_2 = 0.375$ m We have, $\sin\alpha = \frac{r_2 - r_1}{x} = \frac{0.375 - 0.125}{1.25}$ $\therefore \alpha = 11.53^\circ$ $\therefore 2\alpha = 23.07^\circ$ $\therefore$ Angle of lap $\theta = 180 - 2\alpha$ $= 156.9^\circ$ $= 2.73$ rad Velocity $v = \frac{\pi d_1 N_1}{60} = 7.85$ m/sec Power $P = (T_1 - T_2) \cdot v$ $\therefore T_1 - T_2 = 1275.90$ ----(1) Also, $\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25 \times 2.73} = 1.94$ ---(2) from eqn (1) & (2) $T_1 = 1913.3$ N & $T_2 = 667$ N Now, $T_1 = \sigma \times b \times t = 2.5 \times b \times 12$ $\therefore b = 63.77$ mm Note:- If Prob is solved considering m & T_c, give full credit ----------
Q 6a)(i)	4	Question: **(i) Define 'Gear Train'. State its purpose and types of gear train.** Answer: **Definition:** When two or more gears are made to mesh with each other to transmit power from one shaft to another. Such a combination is called gear train **Purpose:** The purpose of the train used is To obtain correct & required velocity ratio between driver & driven shafts. To decide upon the relative position of the axes of shafts. To decide upon amount of power to be transmitted between shafts **Types:** Following are the different types of gear trains, depending upon the arrangement of wheels : 1. Simple gear train, 2. Compound gear train, 3. Reverted gear train, and 4. Epicyclic gear train. ----------

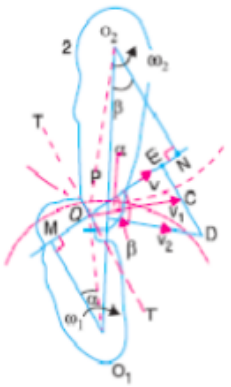
Examination: 2015 WINTER

Que.No	Marks	
Q 1a)(iii)	2	Question: **Define slip and creep in the belt.** Answer: **Slip :** When the frictional grip becomes insufficient. This may cause some forward motion of the driver without carrying the belt with it. This may also cause some forward motion of the belt without carrying the driven pulley with it. This is called slip of the belt and is generally expressed as a percentage. **Creep :** When the belt passes from the slack side to the tight side, a certain portion of the belt extends and it contracts again when the belt passes from the tight side to slack side. Due to these changes of length, there is a relative motion between the belt and the pulley surfaces. This relative motion is termed as creep. ----------
Q 1a)(iv)	2	Question: **State any two advantages of V belt drive over flat belt drive.** Answer: Advantages -1. The V-belt drive gives compactness due to the small distance between the centres of pulleys. 2. The drive is positive, because the slip between the belt and the pulley groove is negligible. 3. Since the V-belts are made endless and there is no joint trouble, therefore the drive is smooth. 4. It provides longer life of 3 to 5 years. 5. It can be easily installed and removed. 6. The operation of the belt and pulley is quiet. 7. The belts have the ability to cushion the shock when machines are started. 8. The high velocity ratio (maximum 10) may be obtained. 9. The wedging action of the belt in the groove gives high value of limiting ratio of tensions. Therefore the power transmitted by V-belts is more than flat belts for the same coefficient of friction, arc of contact and allowable tension in the belts. 10. The V-belt may be operated in either direction with tight side of the belt at the top or bottom. The centre line may be horizontal, vertical or inclined. ----------

Que.No	Marks	
Q 1b)(iii)	4	Question: **Draw the neat sketch of epicyclic gear train and explain how it works.** Answer: In an epicyclic gear train, the axes of the shafts, over which the gears are mounted, may move relative to a fixed axis. A simple epicyclic gear train is shown in Fig. where a gear A and the arm C have a common axis at 1 about which they can rotate. The gear B meshes with gear A and has its axis on the arm at O2, about which the gear B can rotate. If the arm is fixed, the gear train is simple and gear A can drive gear B or viceversa, but if gear A is fixed and the arm is rotated about the axis of gear A (i.e. O1), then the gear B is forced to rotate ***upon*** and ***around*** gear A. Such a motion is called epicyclic and the gear trains arranged in such a manner that one or more of their members moves upon and around another member are known as ***epicyclic gear trains*** (***epi -*** means upon and ***cyclic*** means around). The epicyclic gear trains may be ***simple or compound.***  The epicyclic gear trains are useful for transmitting high velocity ratios with gears of moderate size in a comparatively lesser space. The epicyclic gear trains are used in the back gear of lathe, differential gears of the automobiles, hoists, pulley blocks, wrist watches etc. ----------

Que.No	Marks	
Q 3 c)	4	Question: **State the formulae to calculate the length of open belt drive and cross belt drive. State the meaning of each term by drawing suitable diagrams in both cases.** Answer: **Formulae to calculate the length of open belt drive :**  $L = \pi(r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{x}$ Where, r_1 and r_2 = Radii of the larger and smaller pulleys, x = Distance between the centres of two pulleys (*i.e.* O_1 O_2), L = Total length of the belt. α = angle of **lap** **Formulae to calculate the length of Cross belt drive**  $L = \pi(r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{x}$ Where, r_1 and r_2 = Radii of the larger and smaller pulleys, x = Distance between the centres of two pulleys (*i.e.* O_1 O_2), L = Total length of the belt. α = angle of **lap** ----------

Que.No	Marks	
Q 4 a)	4	Question: **What is centrifugal tension ? State its formula. Explain its effect on power transmitted by a belt drive.** Answer: Since the belt continuously runs over the pulleys, therefore, some centrifugal force is caused, whose effect is to increase the tension on both, tight as well as the slack sides. The tension caused by centrifugal force is called *centrifugal tension*. **Centrifugal Tension Tc = m.v^2**  Power, P = (T_1 - T_2) x v Hence there is no any effect on power transmitted by a belt drive. ---
Q 5 c)	8	Question: **Two parallel shafts whose centre line are 4.8 m apart, are connected by open belt drive. The diameter of larger pulley is 1.5 m and that of smaller pulley 1 m. The initial tension in the belt when stationary is 3 kN. The mass of the belt is 1.5 kg/m length. The coefficient of friction between the belt and pulley is 0.3 Taking centrifugal tension into account, calculate the power transmitted when the smaller pulley rotates at 400 rpm.** Answer: We know that velocity of the belt, $v = \frac{\pi d_2 . N_2}{60} = \frac{\pi \times 1 \times 400}{60} = 21 \text{ m/s}$ and centrifugal tension, $T_C = m.v^2 = 1.5\,(21)^2 = 661.5 \text{ N}$ Let T_1 = Tension in the tight side, and T_2 = Tension in the slack side. We know that initial tension (T_0), $3000 = \frac{T_1 + T_2 + 2T_C}{2} = \frac{T_1 + T_2 + 2 \times 661.5}{2}$ $\therefore \quad T_1 + T_2 = 3000 \times 2 - 2 \times 661.5 = 4677 \text{ N}$ ...(i) For an open belt drive, $\sin\alpha = \frac{r_1 - r_2}{x} = \frac{d_1 - d_2}{2x} = \frac{1.5 - 1}{2 \times 4.8} = 0.0521$ or $\alpha = 3°$ $\therefore$ Angle of lap on the smaller pulley, $\theta = 180° - 2\alpha = 180° - 2 \times 3° = 174°$ $= 174° \times \pi / 180 = 3.04$ rad We know that $2.3 \log\left(\frac{T_1}{T_2}\right) = \mu.\theta = 0.3 \times 3.04 = 0.912$ $\log\left(\frac{T_1}{T_2}\right) = \frac{0.912}{2.3} = 0.3965$ or $\frac{T_1}{T_2} = 2.5$ ...(ii) ...(Taking antilog of 0.3965) From equations (i) and (ii), $T_1 = 3341 \text{ N}$; and $T_2 = 1336 \text{ N}$ $\therefore$ Power transmitted, $P = (T_1 - T_2)\, v = (3341 - 1336)\, 21 = 42\,100 \text{ W} = 42.1 \text{ kW}$ Ans. ---

Que.No	Marks	
Q 6a)(i)	4	Question: **State and explain law of gearing with the help of suitable sketch.** Answer: **Law of gearing:** Consider the portions of the two teeth, one on the wheel 1 (or pinion) and the other on the wheel 2, as shown by thick line curves in Fig. Let the two teeth come in contact at point Q, and the wheels rotate in the directions as shown in the figure. Let $T\ T$ be the common tangent and MN be the common normal to the curves at the point of contact Q. From the centres O_1 and O_2, draw O_1M and O_2N perpendicular to MN. A little consideration will show that the point Q moves in the direction QC, when considered as a point on wheel 1, and in the direction QD when considered as a point on wheel 2. Let v_1 and v_2 be the velocities of the point Q on the wheels 1 and 2 respectively. If the teeth are to remain in contact, then the components of these velocities along the common normal MN must be equal.  Law of gearing. $\therefore \quad v_1 \cos\alpha = v_2 \cos\beta$ or $\quad (\omega_1 \times O_1Q)\cos\alpha = (\omega_2 \times O_2Q)\cos\beta$ $(\omega_1 \times O_1Q)\frac{O_1M}{O_1Q} = (\omega_2 \times O_2Q)\frac{O_2N}{O_2Q}$ or $\omega_1 \times O_1M = \omega_2 \times O_2N$ $\therefore \quad \frac{\omega_1}{\omega_2} = \frac{O_2N}{O_1M}$ ...(i) Also from similar triangles O_1MP and O_2NP, $\frac{O_2N}{O_1M} = \frac{O_2P}{O_1P}$ ...(ii) Combining equations (i) and (ii), we have $\frac{\omega_1}{\omega_2} = \frac{O_2N}{O_1M} = \frac{O_2P}{O_1P}$ ...(iii) From above, we see that the angular velocity ratio is inversely proportional to the ratio of the distances of the point P from the centres O_1 and O_2, or the common normal to the two surfaces at the point of contact Q intersects the line of centres at point P which divides the centre distance inversely as the ratio of angular velocities. Therefore in order to have a constant angular velocity ratio for all positions of the wheels, the point P must be the fixed point (called pitch point) for the two wheels. In other words, *the common normal at the point of contact between a pair of teeth must always pass through the pitch point.* This is the fundamental condition which must be satisfied while designing the profiles for the teeth of gear wheels. It is also known as *law of gearing.* ----------