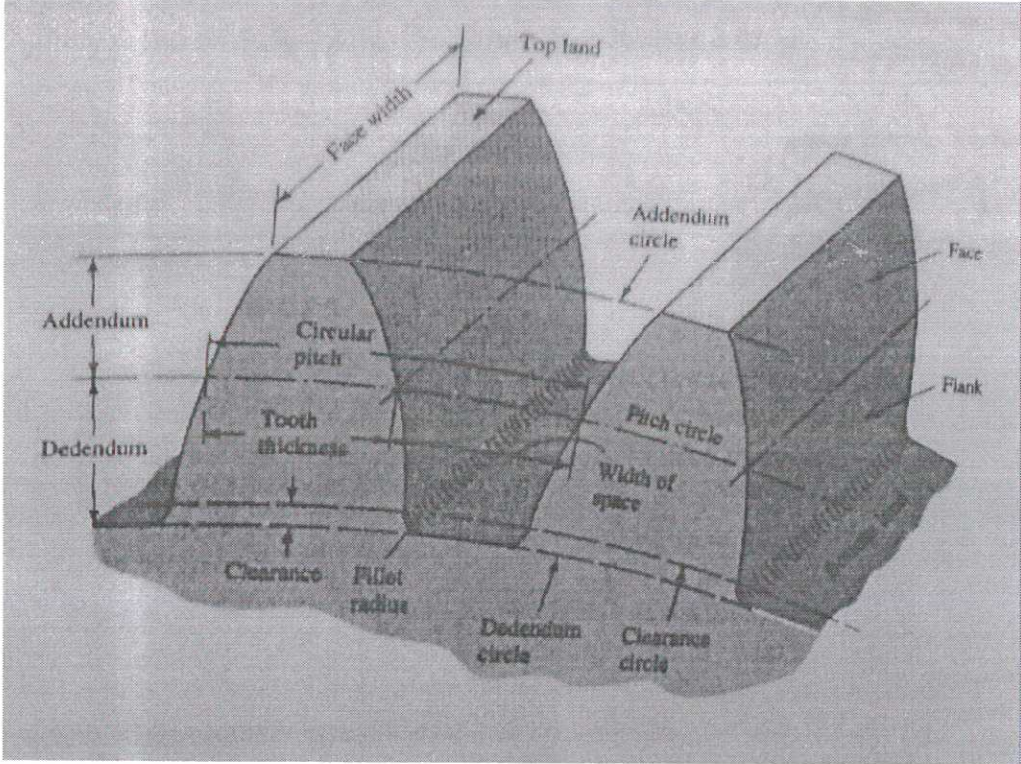


SCHEME OF VALUATION

(scoring Indicators)

Revision: 2015		Course Code : 5021		
Course Title : Design of Machine Elements				
Qst No.	Scoring indicator	Split up score	Sub total	Total
PART A				
I(1)	Factor of safety is defined as the ratio of yield stress to the design stress in ductile materials and in brittle materials ,ultimate stress to the design stress	1 1	2	2
I(2)	It is the distance from one point on a screw thread to the corresponding point on the adjacent screw thread measured parallel to the axis of the screw.	2	2	2
I(3)	$T/J=\tau/r=G\theta/l$, where T is the torque, J is the polar moment of inertia, τ is the shear stress, r is the radius of the shaft, G is the modulus of rigidity, θ is the angle of twist and l is the length of shaft	2	2	2
I(4)	Sensitiveness is defined as the ratio of the mean equilibrium speed to the difference between the maximum and minimum equilibrium speeds.	2	2	2
I(5)	(i)Simple gear train, (ii)Compound gear train, (iii)Reverted gear train , (iv)Epicyclic gear train	$4 \times (\frac{1}{2})$	2	2
PART B				
II(1)	The cross sectional area at the root of the threaded portion of the bolt is the weakest part than that in the shank and maximum amount of elastic energy is absorbed in this region. The ideal bolt will be one which is subjected to same stress level at different cross sections in the bolt. It is called the bolt of uniform strength. To make uniform strength (1)Diameter of the shank is reduced to the core diameter of the threads (2)Cross sectional area of the shank is reduced to the cross sectional area of the root by an axial hole is drilled through the head	4 2	6	6

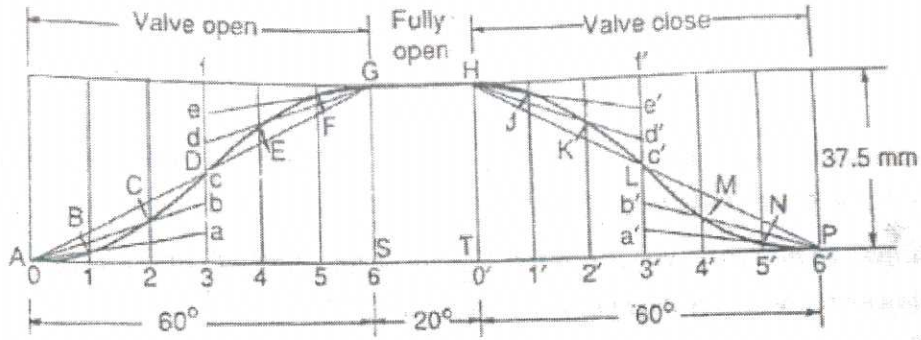
II(4)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%; text-align: center;">Flywheel</th> <th style="width: 50%; text-align: center;">Governor</th> </tr> </thead> <tbody> <tr> <td style="vertical-align: top;"> <ol style="list-style-type: none"> 1. Flywheel stores and redistributes energy within a cycle to control speed. 2. A flywheel takes care of fluctuations of speed during a cycle. 3. A flywheel works continuously from cycle to cycle 4. A flywheel has no control over the quality and quantity of working agent. 5. A flywheel is not essential element of every prime mover. 6. It is used only in case when there is undesirable cyclic fluctuation of energy output or input. </td> <td style="vertical-align: top;"> <ol style="list-style-type: none"> 1. Governor controls the amount of fuel to an engine to match the load requirements to maintain a specified speed. 2. A governor takes care of speed due to variation of load. 3. A governor works intermittently only when there is change in load. 4. A governor takes care of change of quality and quantity of the working agent. 5. A governor is an essential element of every prime mover. 6. It is an adjuster of supply of fuel with demand. </td> </tr> </tbody> </table>	Flywheel	Governor	<ol style="list-style-type: none"> 1. Flywheel stores and redistributes energy within a cycle to control speed. 2. A flywheel takes care of fluctuations of speed during a cycle. 3. A flywheel works continuously from cycle to cycle 4. A flywheel has no control over the quality and quantity of working agent. 5. A flywheel is not essential element of every prime mover. 6. It is used only in case when there is undesirable cyclic fluctuation of energy output or input. 	<ol style="list-style-type: none"> 1. Governor controls the amount of fuel to an engine to match the load requirements to maintain a specified speed. 2. A governor takes care of speed due to variation of load. 3. A governor works intermittently only when there is change in load. 4. A governor takes care of change of quality and quantity of the working agent. 5. A governor is an essential element of every prime mover. 6. It is an adjuster of supply of fuel with demand. 	1x 6	6	6
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II(5)	<ol style="list-style-type: none"> i) Production cost is comparatively high ii) More noisy operation than belt drive iii) Need for accurate mounting and careful maintenance iv) More complicated design than belt drive v) Due to metallic constructions chain drives are heavy vi) These can get stretched occasionally, therefore the links have to be removed 	1x6	6	6				
II(6)		3+3 (3 marks for figure and 3 for marking of important terms)	6	6				

III(b)	<p>Intensity of steam pressure is converted into absolute pressure by means of adding atmospheric pressure to the gauge pressure.</p> <p>Atmospheric Pressure, $p_a = 0.1013 \text{ MPa}$</p> <p>Maximum absolute pressure, $p = p_1 + p_a = 1.4 + 0.1013 = 1.5013 \text{ MPa} = 1.5013 \text{ N/mm}^2$</p> <p>Force acting on the cylinder head, $P = \frac{\pi}{4} D^2 p = \frac{\pi}{4} \times 300^2 \times 1.5013$</p> <p>Resistance offered by the bolts, $P = \frac{\pi}{4} d_c^2 \sigma_t n = \frac{\pi}{4} \times d_c^2 \times 50 \times 12$</p> <p>Equating the relations, $\frac{\pi}{4} \times d_c^2 \times 50 \times 12 = \frac{\pi}{4} \times 300^2 \times 1.5013$</p> $d_c^2 \times 50 \times 12 = 300^2 \times 1.5013$ <p>Core diameter of bolts, $d_c = \sqrt{\frac{300^2 \times 1.5013}{50 \times 12}} = 15.01 \text{ mm}$</p> <p>Nominal diameter, $d = \frac{d_c}{0.84} = \frac{15.01}{0.84} = 17.87 \text{ say } 18 \text{ mm}$</p> <p>Result : Size of the bolt is M18.</p>	1 1 1 1 2 2	8	8
IV(a)	<p>Helix angle, $\alpha = \tan^{-1} \left(\frac{np}{\pi d_m} \right) = \tan^{-1} \left(\frac{1 \times 12.5}{\pi \times 50} \right) = 4.55^\circ$</p> <p>Friction angle, $\phi = \tan^{-1} \mu = \tan^{-1} (0.1) = 5.71^\circ$</p> <p>∴ Effort required at the mean circumference of the threads to lift the load ,</p> $P = W \tan (\alpha + \phi) = 20 \times 10^3 \times \tan (4.55 + 5.71) = 3620.19 \text{ N}$ <p>Using the relation, $T = P^l \times L = P \times \frac{d_m}{2}$</p> <p>∴ Effort applied at the end of the lever to lift the load, $P^l = \frac{Pd_m}{2L} = \frac{3620.19 \times 50}{2 \times 500} = 181.01 \text{ N}$</p> <p>Result : The effort required to lift the load on the end of the lever is 181.01 N.</p>	2 2 1 3	8	8

V(b)	<p>i) It should be capable of transmit torque from the driving machine shaft to the driven machine shaft without any loss</p> <p>ii) It should be permitted easy connection and dis connection of the shafts for the purpose of repairs and alterations</p> <p>iii) It should keep the perfect alignment of the two shafts</p> <p>iv) It should be safe from projecting parts</p> <p><u>Types of couplings</u></p> <ol style="list-style-type: none"> 1) Sleeve or muff coupling 2) Clamp or compression coupling 3) Flange coupling 4) Protected type flange coupling 5) Solid or marine flange coupling <p>(any of the three)</p>	1x4	4	7
VI(a)	<p>Convert the ultimate shear stress into permissible or safe stress.</p> <p>∴ Permissible shear stress, $\tau_b = \frac{\tau_{ub}}{F.S} = \frac{350}{5}$</p> <p>$= 70 \text{ N/mm}^2 = 70 \text{ MPa}$</p> <p>Consider shearing failure of bolts, i.e.,</p> $T_{max} = \frac{\pi}{4} d_1^2 n \tau_b \times \frac{D_p}{2}$ <p>Nominal diameter of bolts, $d_1 = \sqrt{\frac{8T_{max}}{\pi n \tau_b D_p}} = \sqrt{\frac{8 \times 25 \times 10^5}{\pi \times 8 \times 70 \times 120}} = 9.73 \text{ say } 10 \text{ mm}$</p> <p>For which standard bolt of M10 can be used.</p>	3	8	8
VI(b)	<p>Diameter of shaft, $d = 60 \text{ mm}$</p> <p>Speed of shaft, $N = 100 \text{ rpm}$</p> <p>Permissible shear stress, $\tau = 50 \text{ MPa} = 50 \text{ N/mm}^2$</p> <p>Analysis :</p> <p>Using strength equation.</p> <p>Maximum torque, $T = \frac{\pi}{16} \tau d^3 = \frac{\pi}{16} \times 50 \times 60^3 = 2120575.04 \text{ N-mm}$</p> <p>$= 2120575.04 \times 10^{-3} \text{ N-m}$</p> <p>Using the power equation.</p> <p>Power transmitted by the shaft,</p> $P = \frac{2\pi NT}{60} = \frac{2 \times \pi \times 100 \times 2120575.04 \times 10^{-3}}{60}$ <p>$= 22206.6 \text{ W} = 22.21 \text{ kW}$</p> <p>Result :</p> <p>Power transmitted by the shaft is 22.21 kW</p>	$3\frac{1}{2}$	7	

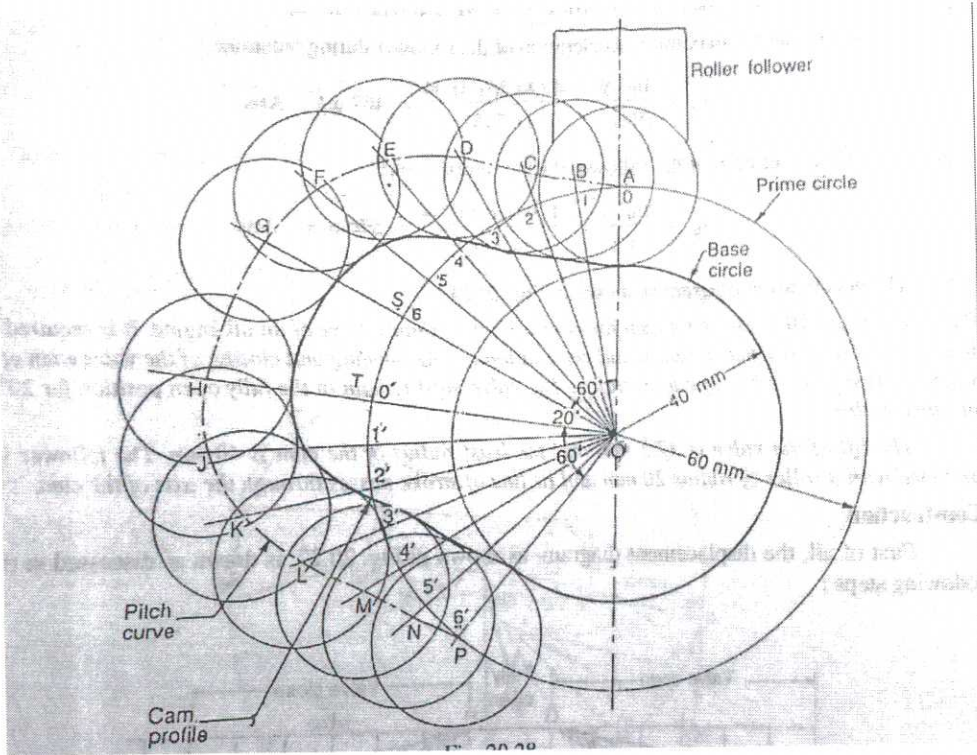
UNIT III

VII(a)



3

Displacement diagram



5

Cam profile

8

8

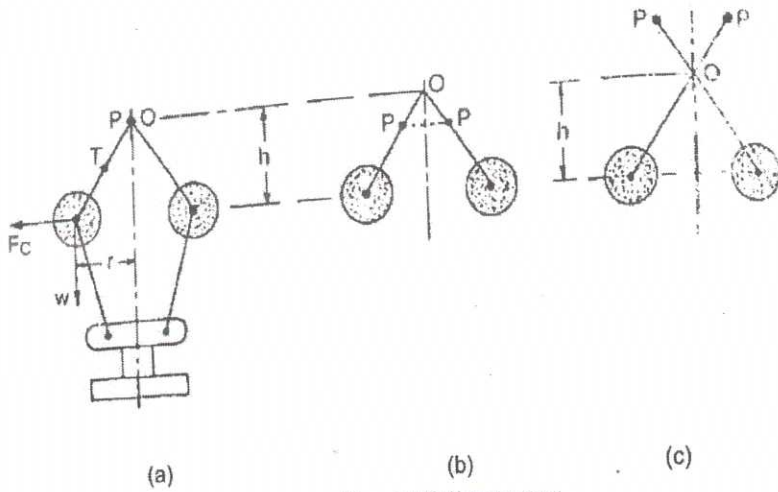


Fig Watt governor

Fig shows three forms of a simple centrifugal or watt governor. It consists of a pair of balls attached to the spindle with the help of four links or arms. In Fig (a) the upper arms meet at the pivot P which may be on the spindle axis. In Fig (b), the upper arms which may be offset from the spindle axis and are connected by a horizontal link PP and the governor is known as *open-arm type watt governor*. In Fig (c), the upper arms which may be offset from the spindle axis and are connected by a horizontal link PP and the governor is known as *crossed-arm type watt governor*. In this type the upper arms intersect the spindle axis at point O . The lower links or arms in each case are fixed to a sleeve by pin joints and are free to move on the vertical spindle. The movement of sleeve is restricted by means of two stops provided on the spindle. As the spindle rotates, the balls take up a position depending upon the speed of the spindle. The speed of rotation of balls increases as the load on the engine decreases and the governor balls fly outwards from the spindle axis due to increase in the centrifugal force on the fly balls. At the same time the sleeve is able to rise on the spindle and the movement of the sleeve is further regulated the throttle valve of the engine by means of a suitable linkage to decrease the supply of working fluid. On the

other hand the speed of rotation of balls decreases as the load on the engine increases and the governor balls move near to the spindle axis due to reduction in the centrifugal force on the fly balls. At that time the sleeve is able to descend on the spindle and to increase the supply of working fluid.

VIII(a)	<p>Using the equation for bearing pressure in journal bearings, i.e., $p = \frac{W}{ld}$</p> <p>Length of the bearing, $l = \frac{W}{pd} = \frac{150 \times 10^3}{1.6 \times 300} = 312.5 \text{ mm}$</p> <p>Using McKee equation for coefficient of friction</p> $\mu = \frac{33}{10^8} \left(\frac{ZN}{p} \right) \left(\frac{d}{c} \right) + k = \frac{33}{10^8} \left(\frac{0.02 \times 1800}{1.6} \right) \left(\frac{300}{0.25} \right) + 0.002 = 0.011$ <p>Using the equation for rubbing velocity, $v = \frac{\pi dN}{60} = \frac{\pi \times 300 \times 10^{-3} \times 1800}{60} = 28.27 \text{ m/s}$</p> <p>Now using the relation for heat generated at bearing</p> $Q_g = \mu Wv = 0.011 \times 150 \times 10^3 \times 28.27 = 46645.5 \text{ J/s}$ $= 46645.5 \times 60 = 2798730 \text{ J/min} = 2798.73 \text{ kJ/min}$ <p>Result :</p> <p>Length of bearing is 312.5 mm and the amount of heat generated in minute is 2798.73 kJ.</p>	1 1 3 1 2	8	8
VIII(b)	<p>The difference between the maximum and minimum angular speeds of the flywheel is called <i>maximum fluctuation of speed</i> of the flywheel. The speed variation during a cycle is usually expressed as a coefficient which is known as the <i>coefficient of fluctuation of speed</i>. The ratio of maximum fluctuation of speed to the mean speed is called the coefficient of fluctuation of speed.</p> $\text{Coefficient of fluctuation of speed} = \frac{\text{Maximum speed} - \text{Minimum speed}}{\text{Mean speed}}$ $C_s = \frac{\omega_1 - \omega_2}{\omega}$ <p>Where</p> <p>ω_1 = Maximum angular speed in rad/s, that is equal to, $\frac{2\pi N_1}{60}$</p> <p>where N_1 is the maximum speed in rpm.</p> <p>ω_2 = Minimum angular speed in rad/s, that is equal to, $\frac{2\pi N_2}{60}$</p> <p>Where N_2 is the minimum speed in rpm.</p>	1(1/2) 1 1	3.5	

	<p>The difference between the maximum and minimum kinetic energies is called the <i>maximum fluctuation of energy</i> of the flywheel. The ratio of maximum fluctuation of energy to the work done per cycle is called <i>coefficient of fluctuation of energy</i>.</p> <p>Coefficient of fluctuation of energy = $\frac{\text{Maximum fluctuation energy}}{\text{Workdone per cycle}}$</p> $C_e = \frac{E_{max} - E_{min}}{T_{mean} \times \theta} = \frac{\Delta E}{T_{mean} \times \theta}$ <p>Where</p> <p>E_{max} and E_{min} = Maximum and minimum kinetic energy in the flywheel in N-m or Joules</p> <p>T_{mean} = Mean torque in N-m,</p> <p>T_{mean} may be obtained by using power equation ,i.e.,</p> $T_{mean} = \frac{60P}{2\pi N} = \frac{P}{\omega} \quad \left(\because \omega = \frac{2\pi N}{60} \right)$ <p>θ = Angle turned in one revolution in radians.</p> <p>= 2π for steam engine and two stroke internal combustion engines.</p> <p>= 4π for four stroke internal combustion engines.</p>	1(1/2)		
		1	$3\frac{1}{2}$	7
		1		
IX(a)	<p>$d=600 \text{ mm}, N=200 \text{ rpm}, \mu=0.25, \Theta=160 \times (\pi/180)=2.79 \text{ rad}$</p> <p>$T1=2.5 \text{ kN}$</p> <p>$P=T1(1-(1/e^{\mu\Theta})\pi DN/60=2.5 \times 10^3(1-(1/e^{0.25 \times 2.79})) \times (3.14 \times 0.6 \times 200)/60=7888.09 \text{ W}=7.89 \text{ kW}$</p>	1		
		7	8	8
IX(b)	<ol style="list-style-type: none"> 1. They give positive drives and constant speed ratio without any slippage 2. The drive is more compact due to shorter centre distance used in such drives 3. Can be operated at higher speeds 4. High efficiency, reliable in service and simple in operation 5. Lighter loads on the shafts and bearings 6. Used where precise timing is desired 7. Wide range of power transmitted 8. Maintenance is inexpensive 9. Can be used for non intersecting and non parallel shafts <p>(any seven)</p>	1x7	7	7
X(a)	<p>$C=600 \text{ mm}, N1=150 \text{ rpm}, N2=600 \text{ rpm}, m=6 \text{ mm}$</p> <p>$N1/N2=T2/T1=d2/d1$</p> <p>$d2/d1=N1/N2=150/600=1/4$</p> <p>$d1=4d2$(1)</p> <p>$C=(d1+d2)/2$,</p> <p>$d1+d2=2 \times 600=1200$.....(2)</p> <p>$4d2+d2=5d2=1200$</p> <p>Pitch circle dia $d2=1200/5=240 \text{ mm}$</p> <p>Substituting in (1) $d1=4 \times 240=960 \text{ mm}$</p> <p>$m=d1/T1=d2/T2$</p> <p>$T1=d1/m=960/6=160$</p> <p>Number of teeth on second gear $T2=d2/m=240/6=40$</p> <p>Number of teeth on gear wheels are 160 and 40</p>	1 1 1 1 1 1 2	8	8

Compound Gear Train

When there are more than one gear on a shaft, as shown in Fig. it is called a *compound train of gear*.

it is called a *compound*

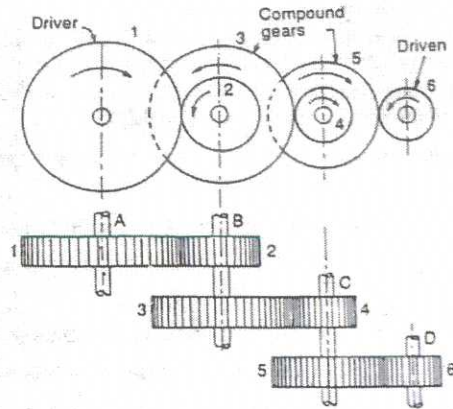


Fig. Compound gear train.

But 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. In this case, each intermediate shaft has two gears rigidly fixed to it so that they may have the same speed. One of these two gears meshes with the driver and the other with the driven or follower attached to the next shaft as shown in Fig.

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 compound gears which are mounted on shaft C and the gear 6 is the driven gear mounted on shaft D.

Let N_1 = Speed of driving gear 1,
 T_1 = Number of teeth on driving gear 1,
 N_2, N_3, \dots, N_6 = Speed of respective gears in r.p.m., and
 T_2, T_3, \dots, T_6 = Number of teeth on respective gears.

Since gear 1 is in mesh with gear 2, therefore its speed ratio is

$$\frac{N_1}{N_2} = \frac{T_2}{T_1} \quad \dots (i)$$

Similarly, for gears 3 and 4, speed ratio is

$$\frac{N_3}{N_4} = \frac{T_4}{T_3} \quad \dots (ii)$$

and for gears 5 and 6, speed ratio is

$$\frac{N_5}{N_6} = \frac{T_6}{T_5} \quad \dots (iii)$$

The speed ratio of compound gear train is obtained by multiplying the equations (i), (ii) and (iii).

$$\therefore \frac{N_1}{N_2} \times \frac{N_3}{N_4} \times \frac{N_5}{N_6} = \frac{T_2}{T_1} \times \frac{T_4}{T_3} \times \frac{T_6}{T_5} \quad \text{or} \quad \frac{N_1}{N_6} = \frac{T_2 \times T_4 \times T_6}{T_1 \times T_3 \times T_5}$$

i.e.,

$$\text{Speed ratio} = \frac{\text{Speed of the first driver}}{\text{Speed of the last driven or follower}} = \frac{\text{Product of the number of teeth on the drivers}}{\text{Product of the number of teeth on the driven}}$$