CMR INSTITUTE OF TECHNOLOGY	USN										CMRIT

Internal Assesment Test - II

Sub:	KINEMATICS OF MACHINES							Code:	15ME42
Date:	17/04/2018	Duration:	90 mins	Max Marks:	50	Sem:	IV – A, B	Branch:	MECH

Assume the missing data wherever required. All Parts of the same question should be answered at one place in sequence.

Marks	OBE	
	CO	RBT

Part – A: Answer any two questions. **[30]**

		Marks	CO	RBT
1	The exhaust valve of a diesel engine has a lift of 62.8mm. It is operated by a cam to give cycloidal motion during opening and closing periods each of which corresponds to 120° of cam rotation. The follower is provided with a roller of 20mm diameter and its line of stroke is radial. Minimum radius of the cam is 25mm. Draw the cam profile. Also determine the maximum velocity and acceleration of the follower during outward stroke, if the speed of the cam is 300rpm clockwise. Diplacement Diagram – 6 marks Cam Profile – 7 marks. Calculation – [Formula – 0.5 marks, Calculation – 0.5 marks] } 1 mark each for Velocity & Acceleration.	15	CO5	L3
2	Draw the cam profile for cam with roller reciprocating follower. The axis of the follower passes through the axis of the cam. Particulars of the cam and follower are the following: Roller diameter = 20mm; Minimum radius of the cam = 25mm; Total lift = 30mm. The cam has to lift the follower with SHM during 180° of cam rotations, and then allow the follower to drop suddenly half way and further return with uniform velocity during the remaining angle of cam rotation. The cam rotates in anti-clock wise direction. Displacement Diagram – 7 marks. Cam Profile – 8 marks.	15	CO5	L3
3	A vertical spindle supplied with a plane horizontal face at its lower end is actuated by a cam keyed to a uniformly rotating shaft. The spindle is raised through a distance of 30mm in one fourth, remains at rest in one fourth, is lowered in one third and remains at rest for the remainder of a complete revolution. Draw the profile assuming the least radius of the cam profile as 25mm and that the spindle moves with uniform acceleration and retardation on both ascent and descent. However during descent, deceleration period is half the acceleration period. The axis of the spindle passes through the cam axis. The cam rotates in anti-clock wise direction. Displacement Diagram – 7 marks. Cam Profile – 8 marks.	15	CO5	L3

Part – B: Answer any two questions. **[10 x 2 = 20]**

4	State and derive the law of gearing. Statement – 2 marks. Diagram – 1 mark. Explanation – 2 marks. Derivation – 5 marks.	10	CO3	L1
5	Define the following with a neat sketch of a gear : a. Working depth b. Addendun c. Root Circle d. Flank e. Tooth thickness f. Circular pitch Sketch – 4 marks. Definition – 1 mark each = 1 × 6 = 6 marks.	10	CO3	L1
6 a.	Define the following with a neat sketch of a cam : a. Pressure angle b. Pitch curve c. Prime circle d. Pitch point Sketch – 2 marks. Definitions – 0.5 mark each = 0.5 × 4 = 2 marks.	04	CO5	L1
6 b.	With neat sketches explain the different types of cam classified according to its shape. 3 Classes – Sketch – 1 mark. Explanation – 1 mark. } 2 marks for each ∴ 3 × 2 marks = 6 marks.	06	CO5	L1

IAT - II

SOLUTION OF KINEMATICS OF MACHINES.

ISME 42.

Part - A

1. The exhaust valve of a diesel engine has a lift of 62.8mm. It is operated by a cam to give cycloidal motion during opening & closing periods each of which corresponds to 120° of cam rotation. The follower is provided with a roller of 20mm diameter & its line of stroke is radial. Minimum radius of the cam is 25mm. Draw the cam profile. Also determine the maximum velocity & acceleration of the follower during outward stroke, if the speed of the cam is 300 rpm clockwise.

Sol^n -

$S = 62.8\,mm$

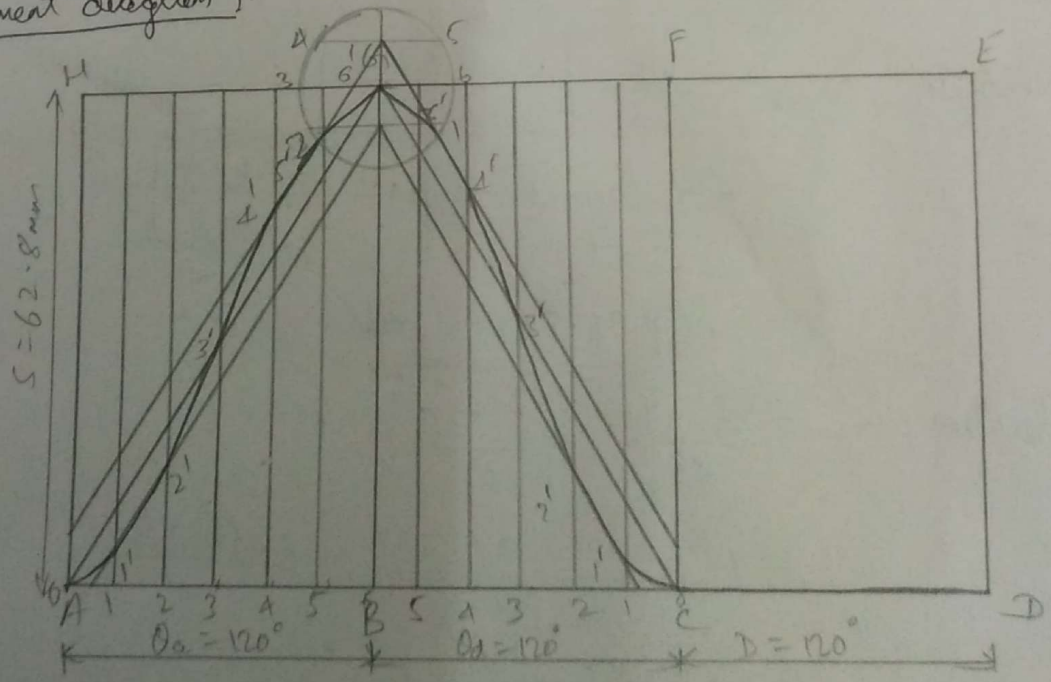
$\theta_a = \theta_d = 120°$

$\phi_R = 20\,mm$

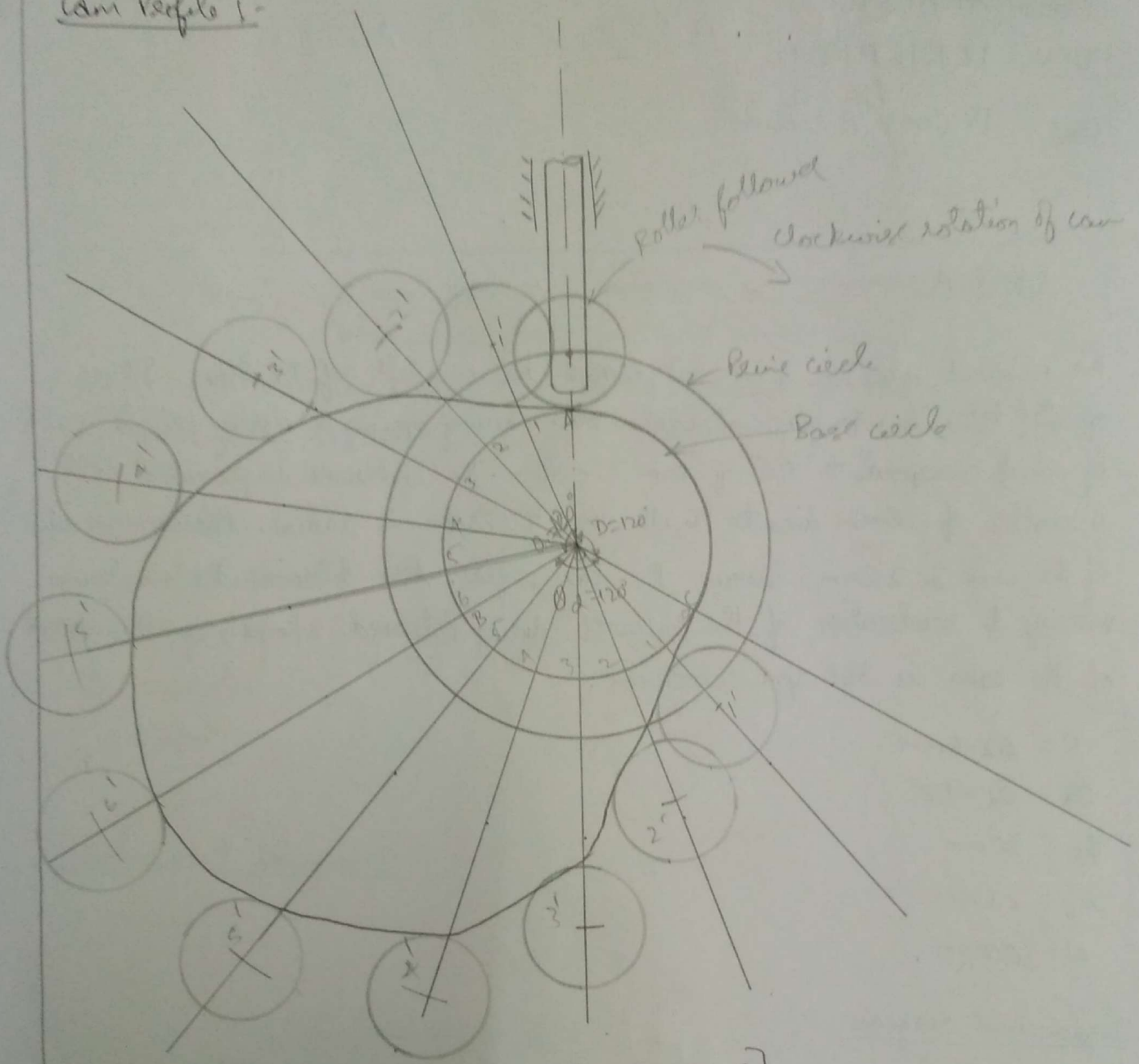
$r_b = 25\,mm$

$N = 300\,rpm$.

Displacement diagram :-



Cam Profile :-



Maximum Velocity, $V_{max} = \frac{\omega S}{\theta_a}\left[1 - \frac{\cos 2\pi\theta}{\theta_a}\right]$

$= \frac{2\pi \times 300 \times 62.8 \times 10^{-3}}{120}\left[1 - \frac{\cos 2\pi \times 60}{120}\right]$

$= 9\,78.59 \times 10^{-3}$ m/s

Maximum acceleration, $a_{max} = \frac{2\pi\omega^2 S}{\theta_a^2} \times \frac{\sin 2\pi\theta}{\theta_a}$

$= \frac{2\pi (2\pi \times 300)^2 \times 62.8 \times 10^{-3}}{120^2} \times \frac{\sin(2\pi \times 60)}{120}$

$= 0.237$ m/s^2

2. Draw the cam profile for cam with roller reciprocating follower. The axis of the follower passes through the axis of the cam. Particulars of the cam & follower are the following:

Roller diameter = 20mm

Minimum radius of the cam = 25mm

Total lift = 30mm.

The cam has to lift the follower with SHM during 180° of cam rotation & then allow the follower to drop suddenly half way & further return with uniform velocity during the remaining angle of cam rotation. The cam rotates in anti-clockwise direction.

Soln 1-

$\phi_r = 20mm$

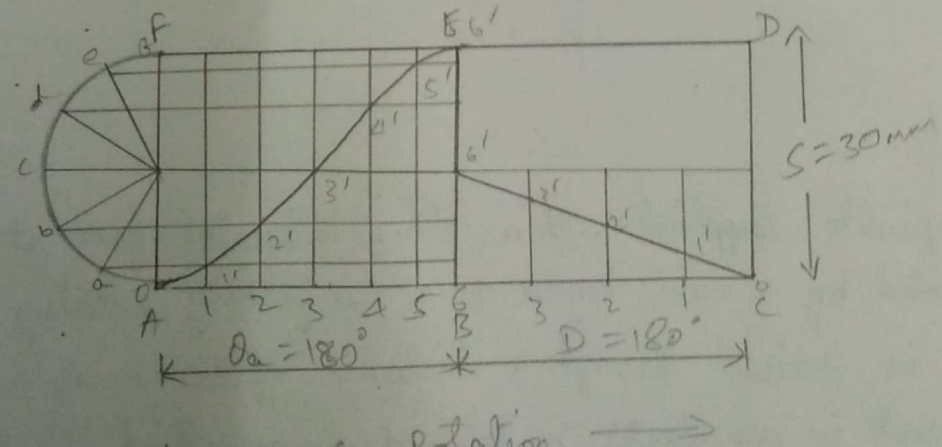
$r_b = 25mm$

$S = 30mm$

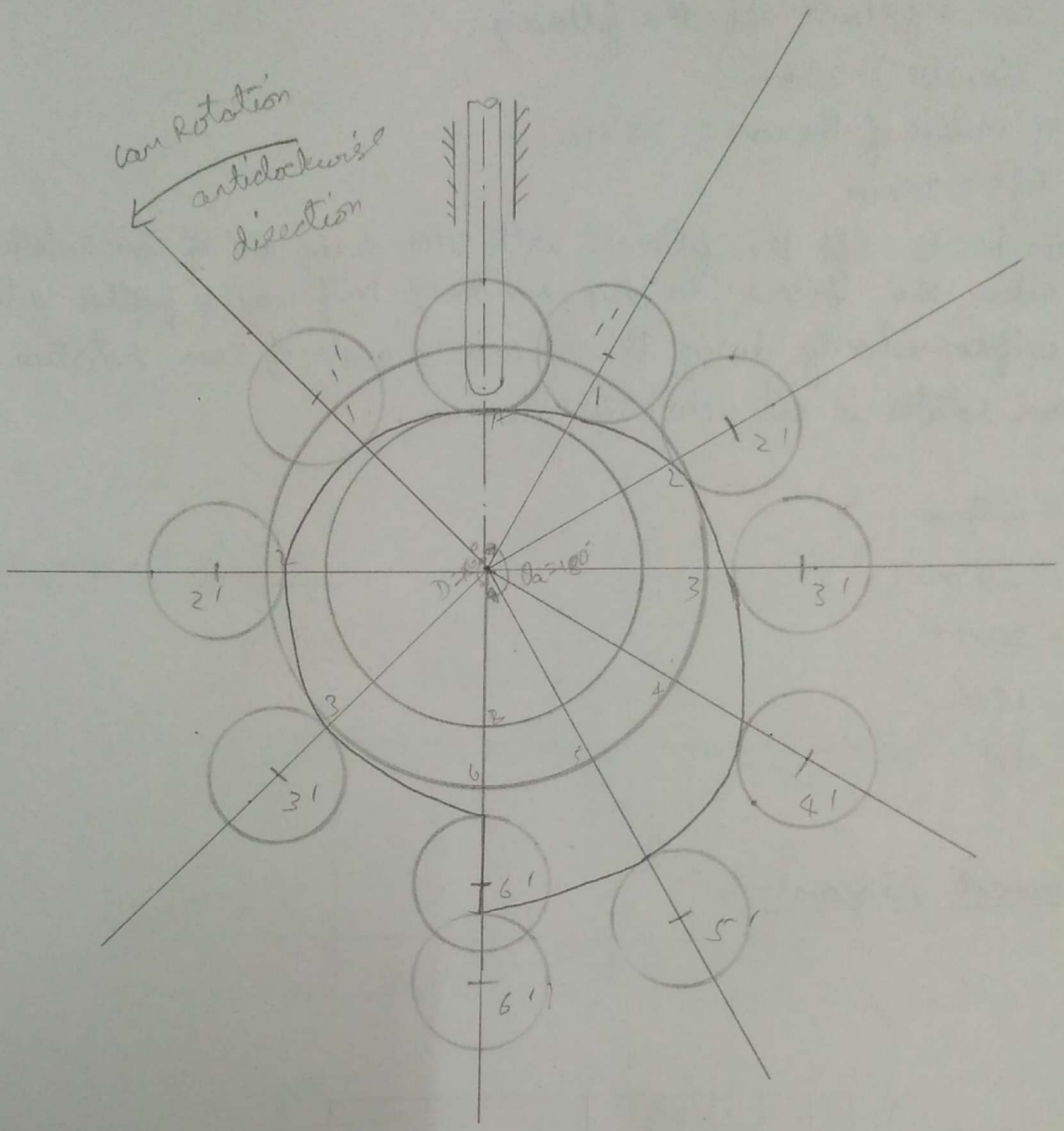
$\theta_a = 180°$

$D = 180°$

Displacement diagram :-



Cam Profile :-



3. A vertical spindle supplied with a plane horizontal face at its lower end is actuated by a cam keyed to a uniformly rotating shaft. The spindle is raised through a distance of 30mm in one-fourth, remains at rest in one-fourth, is lowered in one third & remains at rest for the remainder of a complete rotation. Draw the profile assuming the least radius of cam profile as 25 mm & that the spindle moves with uniform acceleration & retardation on both ascent & decent. However during decent, deceleration period is half the acceleration period. The axis of

the spindle passes through the cam axies. The cam rotates in anti-clockwise direction.

$S = 30mm$

$\theta_a = 90°$

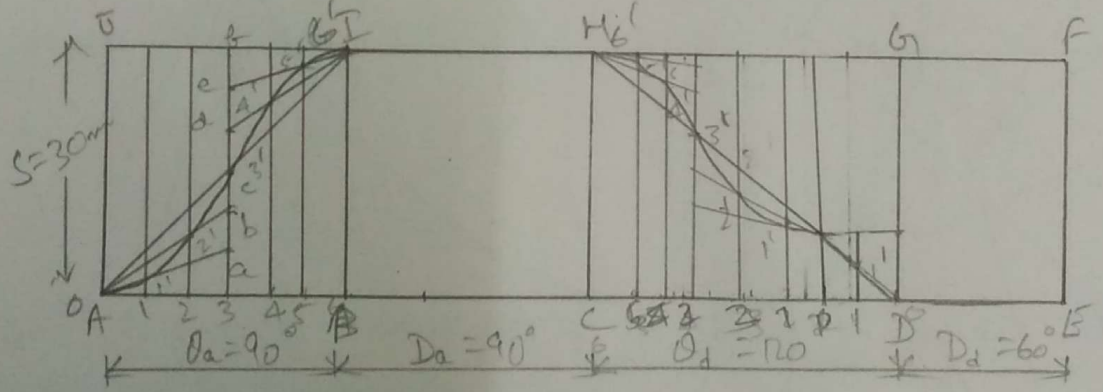
$D_a = 90°$

$\theta_d = 120°$

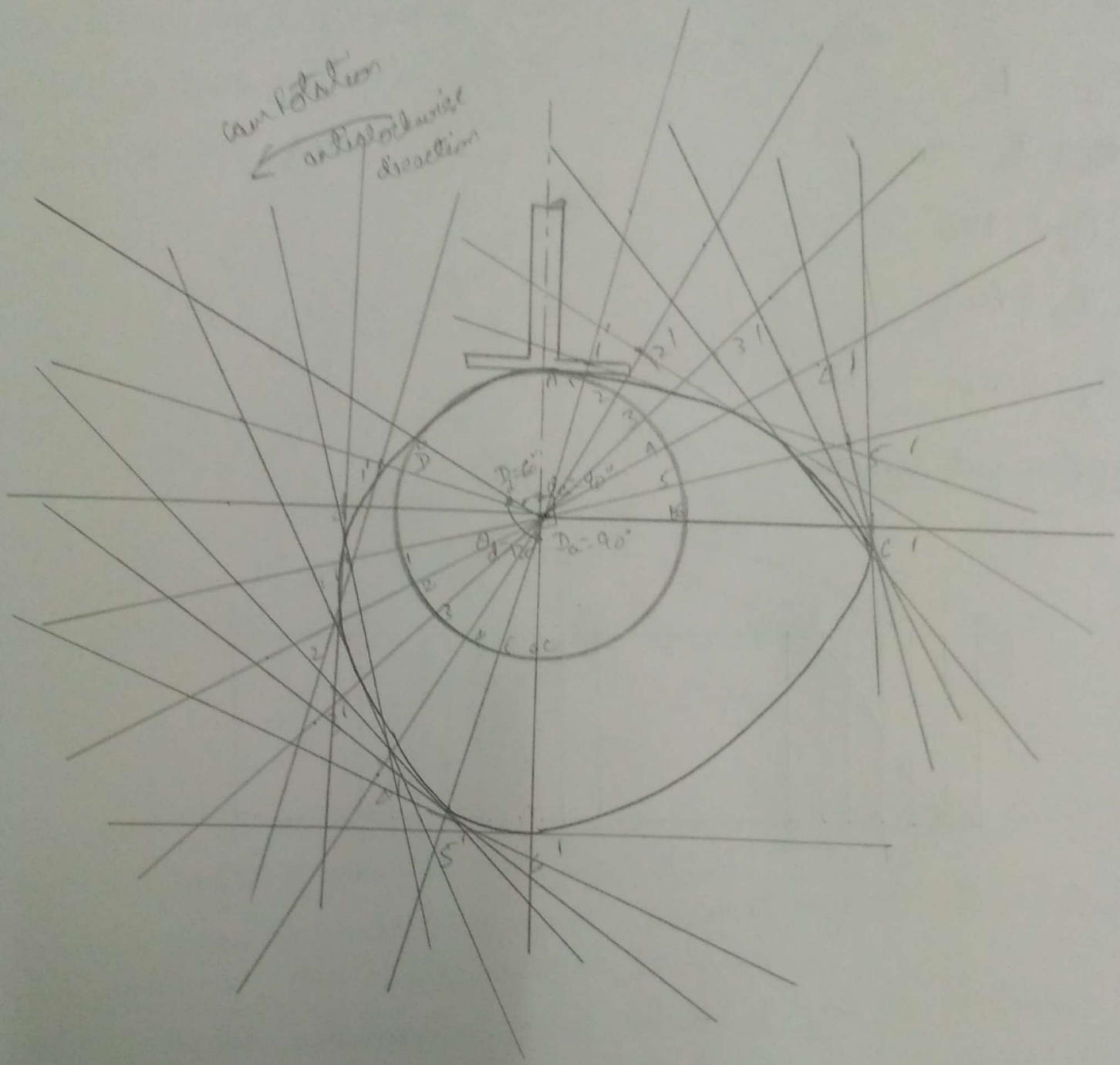
$D_d = 60°$

$R_b = 25mm$

Displacement diagram :-



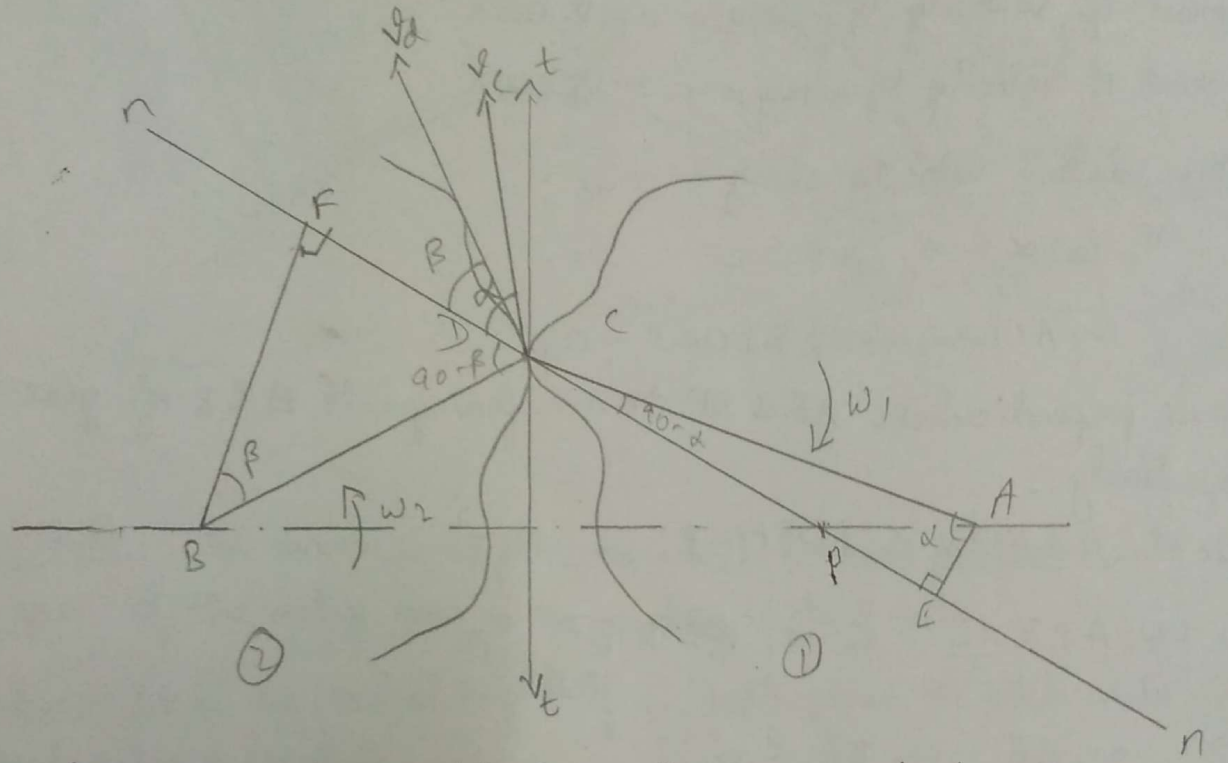
Cam Profiles



Part-B

4. State & derive the laws of gearing:

Ans. **Statement:-** The laws of gearing states the condition which must be fullfilled by the gear tooth profiles in order to maintain a constant angular velocity ratio blw the two gears.



The point C on the tooth profile of gear ① is in contact with a point D on the tooth profile of gear ②.

The two curves in contact at point C & D must have a common normal at that point. Let the common normal be n-n.

Let ω_1 be the instantaneous angular velocity of gear ① clockwise.

ω_2 be the instantaneous angular velocity of gear ② anticlockwise.

v_c be the linear velocity at point C.

v_d be the linear velocity at point D.

We know $v = r\omega$

$\therefore v_c = \omega_1 AC$, in the direction $\perp^r$ to AC or at an angle of α to n-n.

$v_d = \omega_2 \cdot BD$, in the direction $\perp^r$ to BD or at an angle of β to n-n.

If the curved surfaces of the teeth of two gears are to remain in contact, then one surface may slide relative to the other along the common tangent t-t. Hence the relative motion b/w the two surfaces along the common normal n-n must be zero to avoid separation or penetration of the two teeth into each other.

Component of velocity along $n-n = 0$

Component of velocity v_c along $n-n = v_c \cos\alpha$

Component of velocity v_d along $n-n = v_d \cos\beta$

∴ The relative velocity along n-n is:

$$v_c \cos\alpha - v_d \cos\beta = 0$$

$$\omega_1 AC \cos\alpha - \omega_2 BD \cos\beta = 0$$

Draw perpendiculars AE & BF to n-n from points A & B of gears ① & ② respectively.

Hence, $\angle CAE = \alpha$ & $\angle DBF = \beta$

$$\Rightarrow \omega_1 AC \times \frac{AE}{AC} - \omega_2 BD \times \frac{BF}{BD} = 0$$

$$\Rightarrow \omega_1 AE - \omega_2 BF = 0$$

$$\omega_1 AE = \omega_2 BF$$

$$\boxed{\frac{\omega_1}{\omega_2} = \frac{BF}{AE}} \rightarrow (1)$$

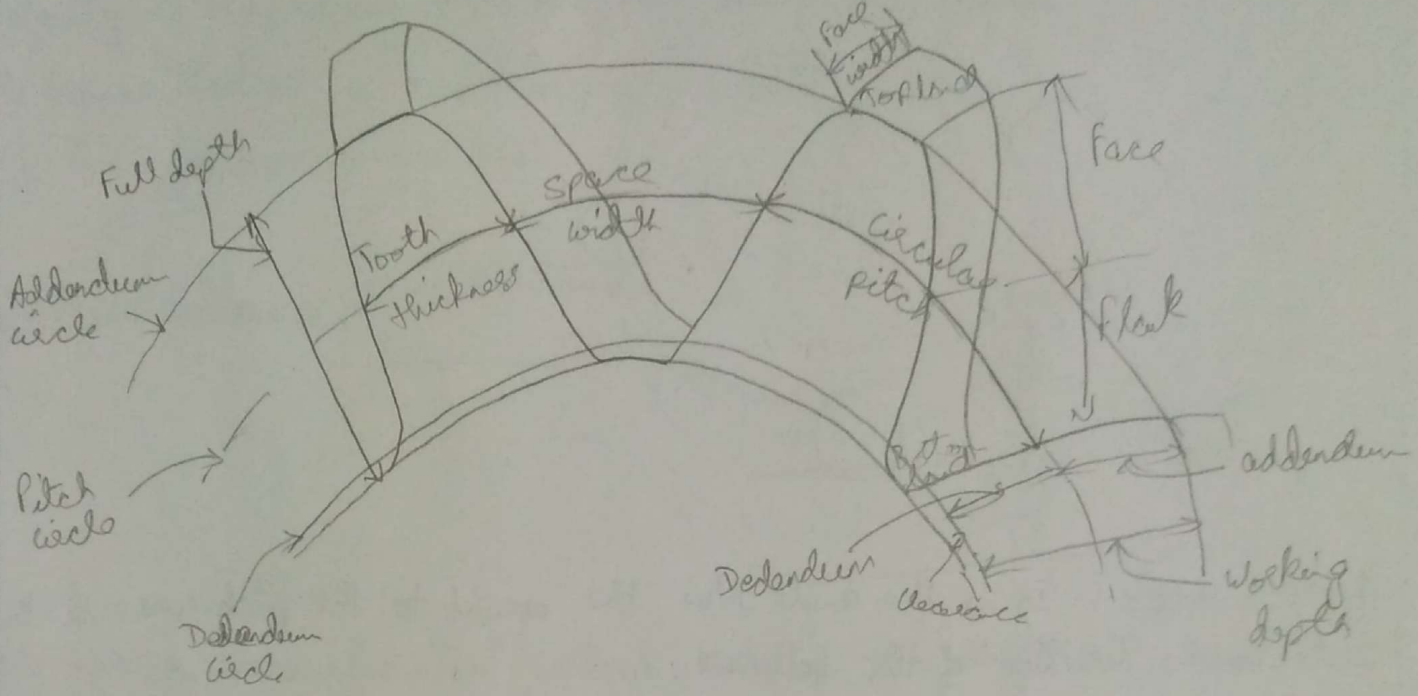
∵ Δ^{le} BFP & Δ^{le} AEP are similar, we have

$$\frac{AE}{BF} = \frac{AP}{BP}$$

$$\Rightarrow \boxed{\frac{\omega_1}{\omega_2} = \frac{BF}{AE} = \frac{BP}{AP}}$$

Thus, it is seen that the centre line AB is divided at point 'P' by the common normal in the inverse ratio of the angular velocities of the two gears.

5. Define the following with a neat sketch of a gear:



g. Working depth :- The maximum depth to which a tooth penetrates into the tooth space of the mating gear is the working depth of teeth.

h. Addendum :- It is the radial height of a tooth above the pitch circle. Its standard value is 1 module.

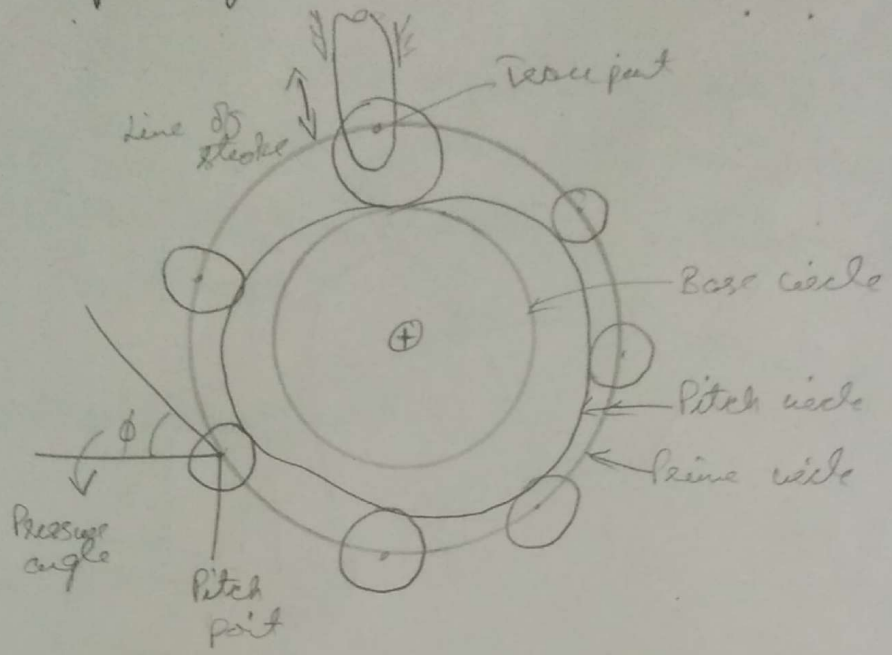
i. Root circle :- It is the circle passing through the root of the teeth.

j. Flank :- Tooth surface b/w the pitch circle & the bottom land including fillet.

k. Tooth thickness :- It is the thickness of the tooth measured along the pitch circle.

l. Circular pitch :- It is the distance measured along the circumference of the pitch circle from a point on one tooth to the corresponding point on the adjacent tooth.

6. a. Define the following with a neat sketch of a cam:



e. Pressure angle :- It is the angle b/w the normal to the pitch curve & the instantaneous direction of the follower.

f. Pitch curve :- It is the path followed by the trace point.

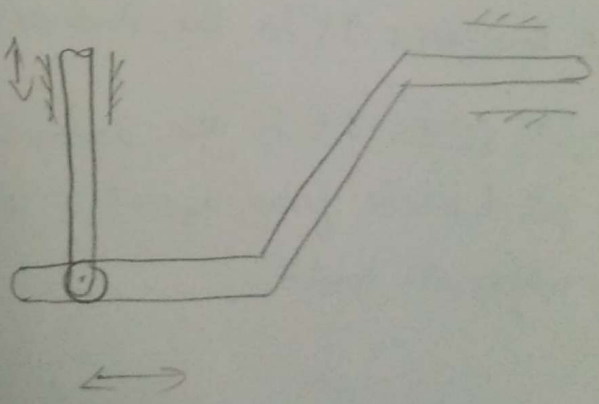
g. Prime circle :- It is the circle along the centre of the roller follower.

h. Pitch point :- It is the point on the pitch curve having maximum pressure angle.

6. b. With neat sketches explain the different types of cam classified according to its shape.

(i) Flat / Plate / Wedge cam :-

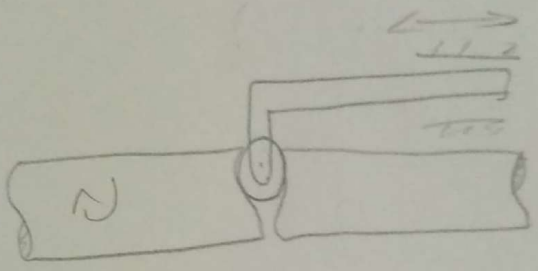
- The translatory motion of the cam is transmitted as the translatory motion of the follower.
- In such cases rather than having continuous rotary motion, they require reciprocating motion. This becomes the limiting factor for its application.



(ii) Radial cams :-

The follower is held in position by a spring or by gravity & the rotary motion of the cam is transformed & transmitted as a translatory or oscillatory motion of the follower.

(iii) Cylindrical follower :-



It has a circumferential contour cut on the surface of a cylinder which rotates about its axis. The follower may translate or oscillate in the direction of the axis