II/IV B.Tech Regular Degree Examination
Mechanical Engineering, Kinematics of Machines
20ME403

1 a) The number of independent coordinates required to completely specify the motion of the body

$M = 3(N-1) - 2J$

(b) If a number of bodies assembled in such a way that the motion of one causes constrained and predictable motion to the others is known as a mechanism.
A machine is a mechanism or a combination of mechanisms which, apart from imparting definite motion to the parts, also transmits and modifies the available mechanical energy into some kind of desired work.

c) Harts straight line mechanism also known as harts inversor is a mechanism that can draw a perfect straight line. The peaucellier - lipkin linkage occupies a imp role in kinematics. it consists of only revolute joints that was capable converting rotary motion to straight line motion and as well as

d) when a point on one link rotates and slides along the other link which rotates then the coriolis component of acceleration will come.

$a_c = 2V\omega$

e) All motions are relative since an arbitrary set of axes or planes is required to define a motion. usually, the earth is taken to be a fixed reference plane and all motions relative to it are termed as absolute motions.

f) $F = 3N - 3G - 2J$ for planar mechanisms
$F = 6N - 6G - 5J_1 - 4J_2 - 3J_3 - 2J_4 - 1J_5$ for spatial mechanisms

g) $V_o = \frac{\pi \omega S}{2\theta_o}$ $V_R = \frac{\pi \omega S}{2\theta_R}$

$a_o = \frac{\pi^2 \omega^2 S}{2(\theta_o)^2}$ $a_R = \frac{\pi^2 \omega^2 S}{2(\theta_R)^2}$

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h) If the line of movement of the follower passes through the centre of rotation of cam, it is known as radial follower
If the line of movement of the follower is offset from the centre of rotation of the cam, the follower is known as an offset follower

i) In the cycloidal profile teeth, the faces of the teeth are epicycloids and the flanks are hypocycloids. An involute is defined as the locus of a point on a straight line which rolls without slipping on the circumference of a circle

j) When the axes of the first gear and the last gear are coaxial, then the gear train is known as reverted gear train.

k) Simple gear train, compound gear train, Reverted gear train, epicyclic gear train

l) Instantaneous centre is the centre about which the body rotates relative to another body at a point of time and it changes w.r.t time.

m) Degree of freedom is zero for the structure and the degree of freedom is positive for the machine.

n). It states that if three links move relatively to each other, they have three instantaneous centres and lie on a straight line.

UNIT I

2 a) Grubler's criterion is used to find out the degrees of freedom of the given linkage based on the number of links and joints and is as follows

$$M = 3N - 3G - 2J$$
$$= 3(N-1) - 2J$$

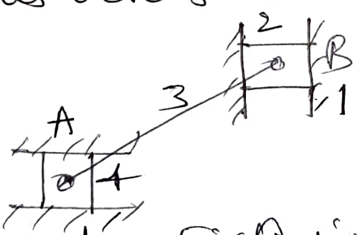
where G = No. of Grounded links
N = No of links
J = No of joints.

The given linkage may comprises of full joints and half joints. A full joint is counted as one and half joint is counted as half. There is some confusion in counting the joints. To avoid confusion Grubblers criterion is modified and the modified equation is called as Kutzback equation and is as follows

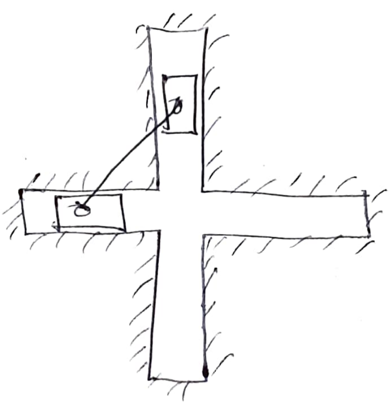
$$M = 3(N-1) - 2J_1 - 1J_2$$

where N = no of links
J_1 = no of full joints
J_2 = no of half joints.

(b) A four bar chain having two turning and two sliding pairs such that two two pairs of the same kind are adjacent is known as a double slider crank chain. The following are its inversions-



First inversion
Elliptical trammel

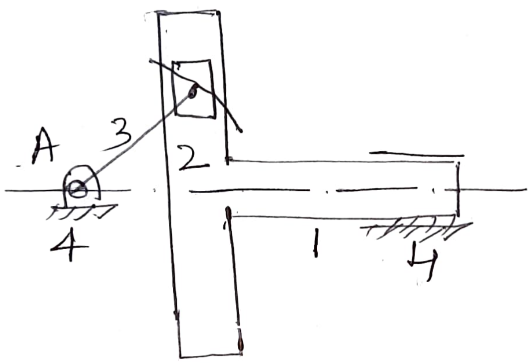


This is obtained when link 1 is fixed and the two adjacent pairs 23 and 34 are turning pairs and the other two pairs 12 and 41 sliding pairs

With the movement of sliders, any point on the link 3 except the mid point of AB will trace ellipse on a fixed plate. The mid point of AB will trace a circle.

Second Inversion

Scotch yoke mechanism



A scotch yoke mechanism is used to convert the rotary motion into a sliding motion.

Third inversion

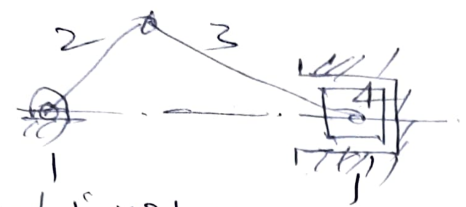
Oldhams coupling

This inversion is obtained when the link 3 of the first inversion is fixed and the link 1 is free to move.

3 a) When one of the turning pairs of a four bar chain is replaced by a sliding pair, it becomes a single slider crank chain.

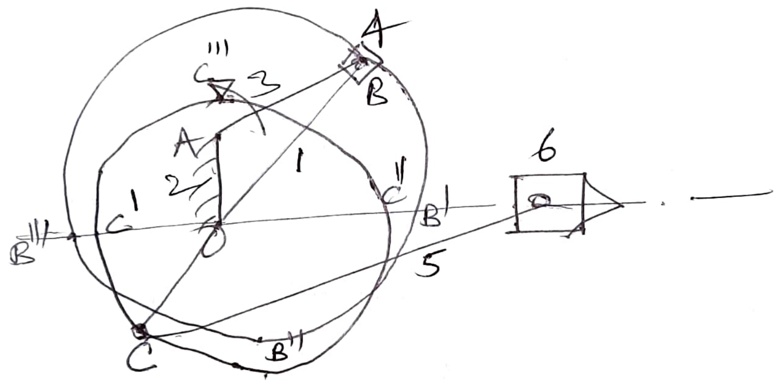
First inversion

This inversion is obtained when link 1 is fixed and links 2 and 4 are made the crank and the slider respectively. The Applications are Reciprocating engine and Reciprocating compressor



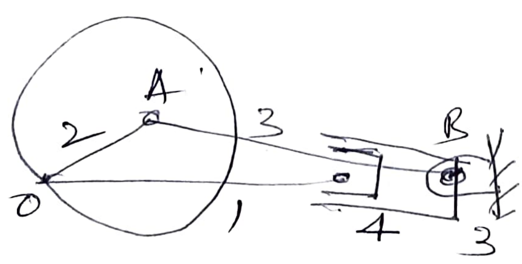
Second inversion

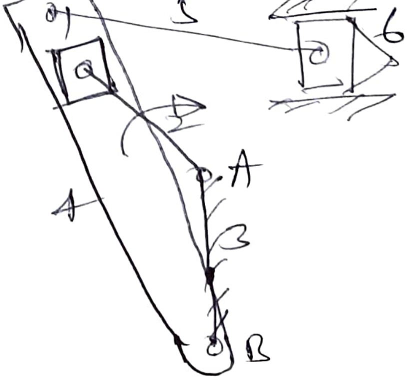
Fixing of link 2 of a slider crank chain results in the second inversion. The application is whitworth quick return motion mechanism.



Third inversion

By fixing link 3 of the slider crank mechanism third inversion is obtained. The application is oscillating cylinder engine and crank and slotted lever mechanism.





Fourth inversion
If link 4 of the slider crank mechanism is fixed, the fourth inversion is obtained. The app is found in Hand pump.

b) There are three types of constrained motion
1. completely constrained motion
2. Partially or successfully constrained motion
3. Incompletely constrained motion.

completely constrained motion is defined as the type of motion where the motion of the pair is limited to only one direction. This is irrespective of the direction of the applied force.

partially or successfully constrained motion is the kind of motion that can be in more than one direction without the influence of any external force.

incompletely constrained motion is the type of motion where the motion between a pair can take place in more than just one direction.

constraints refer to restrictions on an object's motion, position, or both motion and position.

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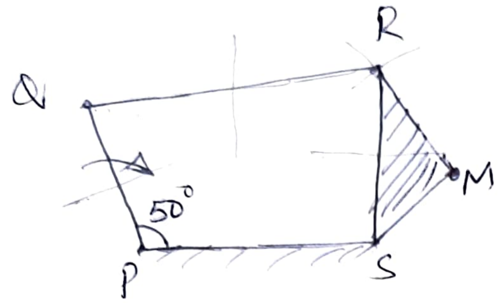
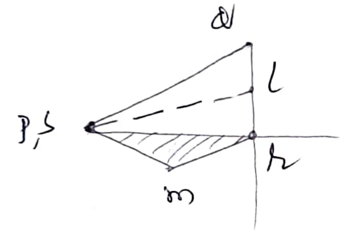
4)



CONFIGURATION DIAGRAM
crank rocker mechanism.



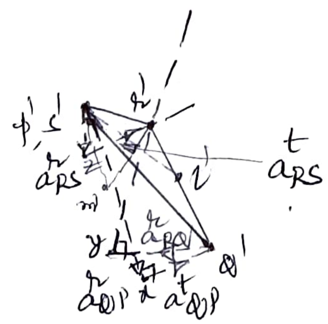
VELOCITY DIAGRAM.

$V_{QP} = QP \times \omega_{QP} = \overline{PQ}$

$V_{RQ} = RQ \times \omega_{RQ} = \overline{Qr}$

$V_{RS} = RS \times \omega_{RS} = \overline{Sr}$

$V_L = \overline{PL} = \overline{SL}$



ACCELERATION DIA

link QP.

$a^r_{QP} = QP \times \omega_{QP}^2$

$V_{QP} = QP \times \omega_{QP}$

$\omega_{QP} = \frac{V_{QP}}{QP} = \frac{\overline{PQ}}{QP}$

$\therefore a^r_{QP} = QP \times \left(\frac{\overline{PQ}}{QP}\right)^2$

$= QP \times \frac{(\overline{PQ})^2}{QP^2}$

$= \frac{(\overline{PQ})^2}{QP}$

$a^t_{QP} = \alpha_{QP} \times QP$

$a_l = p'l'$ or $s'l'$

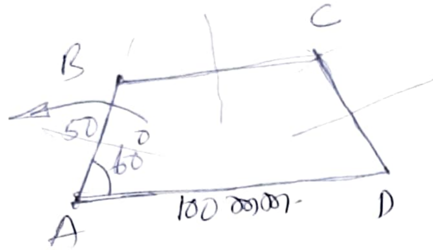
$a_R = p'r'$ & $s'r'$

$a_M = p'm'$ or $s'm'$

5)

AB = 50 mm
BC = 60 mm
CD = 58 mm
AD = 100 mm, fixed link
ω_{AB} = 10.5 rad/sec
α_{AB} = 26 rad/sec²

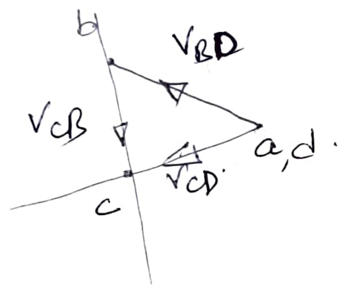
Determine
1) α_{BC}
2) α_{CD}



CONFIGURATION DIAGRAM

Velocity Analysis

$V_{BA} = BA \times \omega_{BA}$
$= \frac{50}{1000} \times 10.5$ m/sec



VELOCITY DIAGRAM

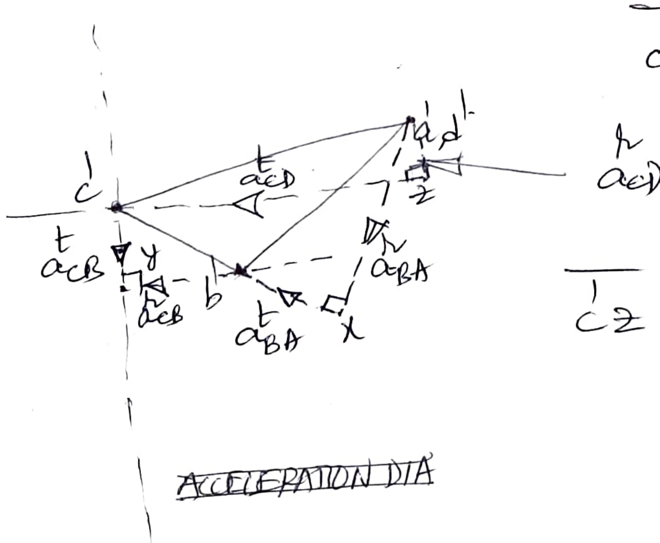
$V_{CB} = CB \times \omega_{CB}$

$\omega_{CB} = \frac{V_{CB}}{CB} = \frac{\overline{bc}}{CB}$

$V_{CD} = CD \times \omega_{CD}$

$\omega_{CD} = \frac{V_{CD}}{CD} = \frac{\overline{dc}}{CD}$

Acceleration analysis



ACCELERATION DIA

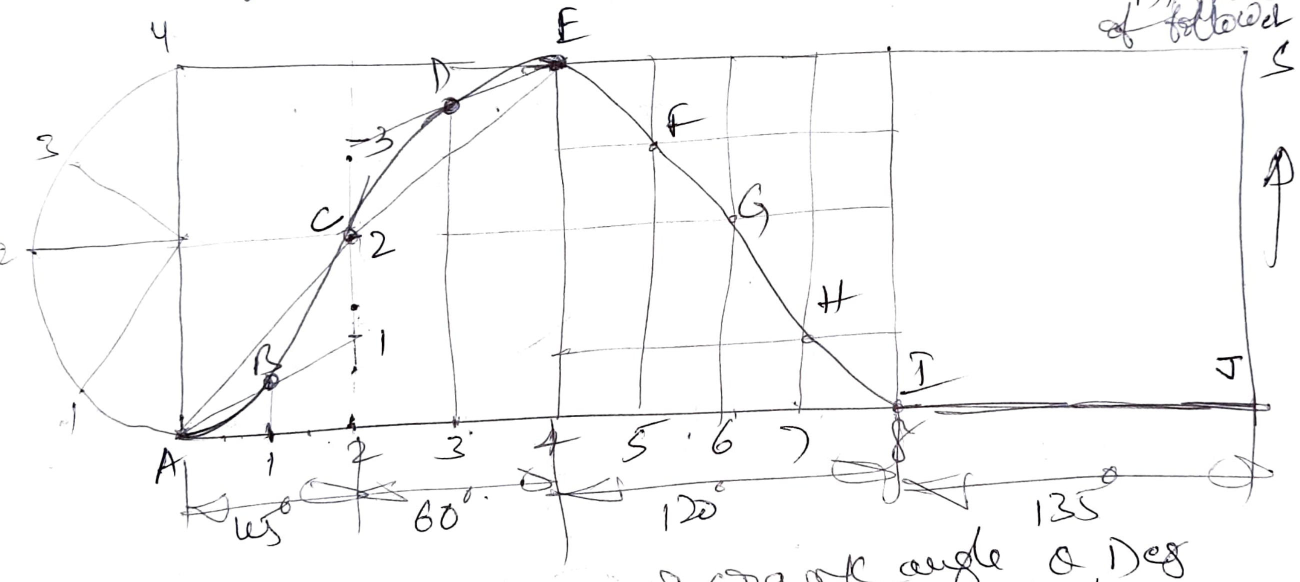
$\overline{c'y} = a^t_{CB} = BC \times \alpha_{BC}$
$\Rightarrow \alpha_{BC} =$

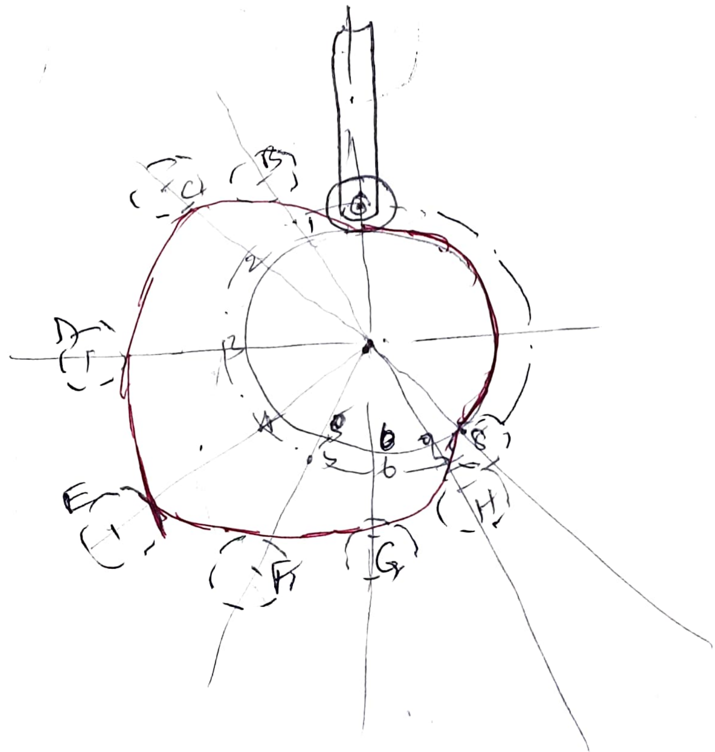
$\overline{c'z} = a^t_{CD} = CD \times \alpha_{CD}$
$\Rightarrow \alpha_{CD} =$

UNIT III

6 cam : radial cam
follower : Roller follower
dia of roller = 30 mm
stroke of follower or lift of follower = S = 35 mm
$\theta_o = 45^0 + 60^0$ → uniform acc and retardation
$\theta_R = 120^0$ → SHM
$\theta_D = 135^0$
least radius of cam = 25 mm.

Displacement dia of follower





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7) Minimum dia of Cam = 30 mm

Follower : Knife edged follower

Stroke of follower = S = 25 mm

$\theta_O = 120^\circ$ → Uniform acc & retardation

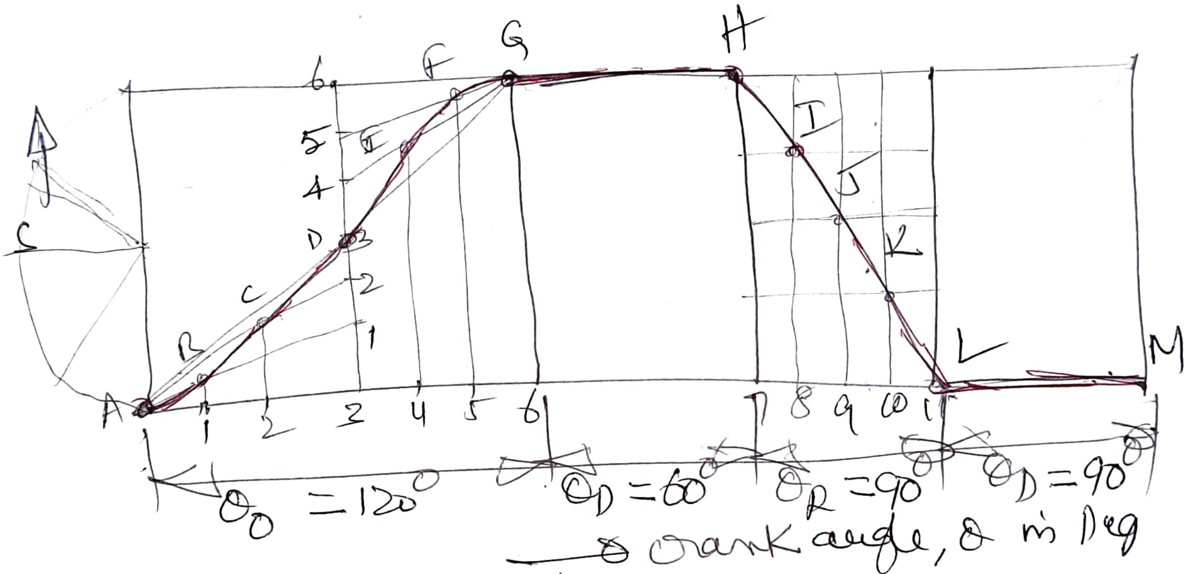
$\theta_D = 60^\circ$

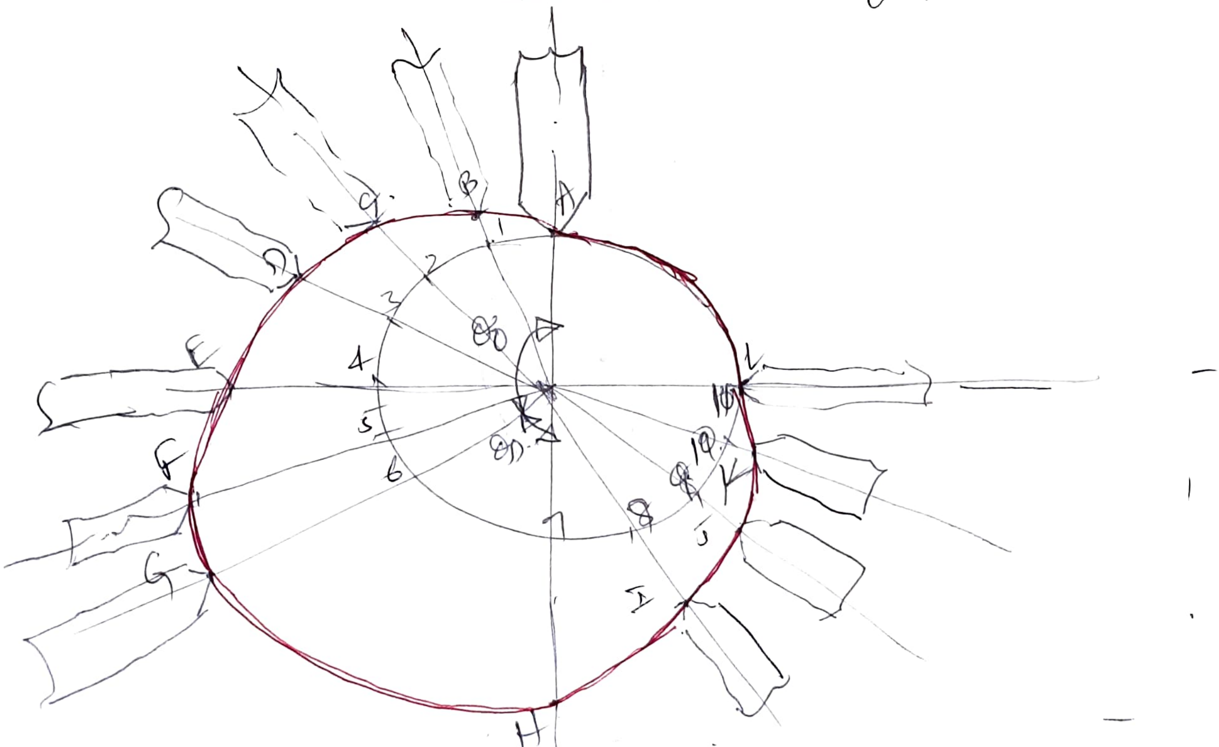
$\theta_R = 90^\circ$ → SHM

$\theta_D = 90^\circ$

Type of cam : Radial cam.

Displacement dia of follower





UNIT IV

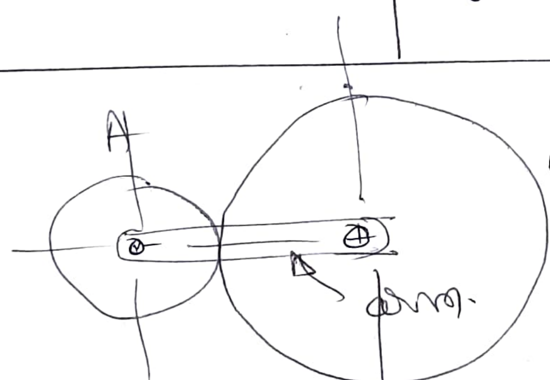
8 Given

$T_A = 36$

$T_B = 45$

$N_C = 150$ rpm

Step No	Condition of motion	Revolution of Elements		
		Arm C	Gear A	Gear B
1	arm fixed - wheel A rotates through +1 revolu in ↺	0	+1	$-\frac{T_A}{T_B}$
2	arm fixed - wheel A rotates through x revolu	0	+x	$-x\frac{T_A}{T_B}$
3	add +y rev to all	+y	+y	+y
		y	x+y	$y - x\frac{T_A}{T_B}$



Speed of gear B when gear A is fixed

$y = +150$ rpm.

$x + y = 0$

$x = -150$

Speed of gear B $= N_B = y - x\frac{T_A}{T_B}$

$= 150 - (-150)\frac{36}{45}$

$= 270$ rpm ↺

Speed of gear B when gear A makes 300 rpm ↻

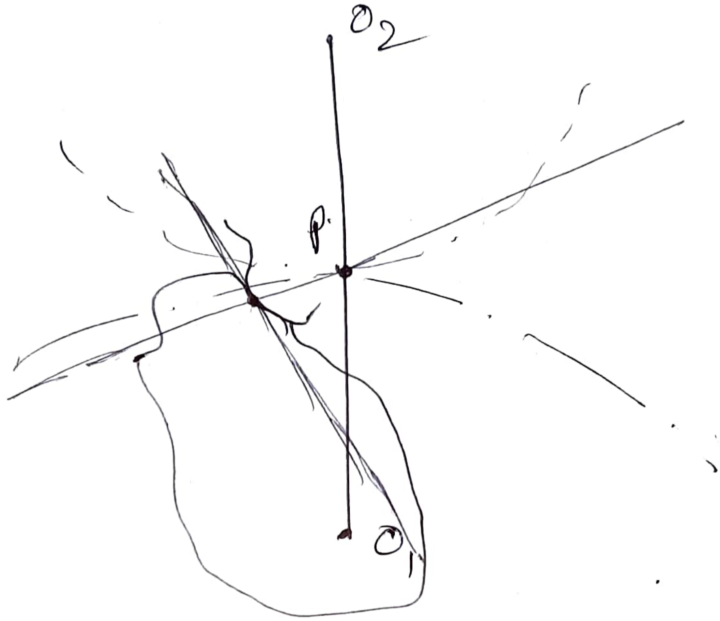
$x + y = 300$

~~y = 450~~ $y = 150$.

~~x = 450~~ $x = -300 - 150 = -450$.

$N_B = y - x\frac{T_A}{T_B} = 150 + 450 \times \frac{36}{45} = +510$ rpm ↻

9 a) 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



b) If the radius of addendum circle of pinion is increased to and the point of contact will also move. When this radius is further increased, the point of contact will be on the inside of the base circle of wheel and not on the involute profile of teeth on wheel. The tip of tooth on the pinion will then undercut the tooth on the wheel at the root and remove part of the involute profile of tooth on the wheel. This effect is known as interference

The interference in the involute gears can be avoided if the minimum no of teeth are provided on wheel and gear. $t_p = \frac{2A_p}{\sqrt{1+G(G+2)\sin^2\phi}-1}$, $t_g = \frac{2A_w}{\sqrt{1+\frac{1}{G}\left(\frac{1}{G}+2\right)\sin^2\phi} \ldots}$