KINEMATICS OF MACHINES

B.E, IV Semester, Mechanical Engineering

[As per Choice Based Credit System (CBCS) scheme]

Course Code	17ME42	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Credits – 04

Course Objectives:

1. **Familiarize with mechanisms and motion analysis of mechanisms.**
2. **Understand methods of mechanism motion analysis and their characteristics.**
3. **Analyse motion of planar mechanisms, gears, gear trains and cams.**

Module - 1

Introduction: Definitions: Link, kinematic pairs,kinematic chain, mechanism, structure, degrees of freedom, Classification links, Classifiction of pairs based on type of relative motion,Grubler's criterion, mobility of mechanism, Groshoff's criteria, inversions of Grashoff's chain.

Mechanisms: Quick return motion mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Oldham's coupling, Straight line motion mechanisms, Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms:Geneva wheel mechanism, Ratchet and Pawl mechanism,toggle mechanism, pantograph, condition for correct steering, Ackerman steering gear mechanism.

Module - 2

Velocity and Acceleration Analysis of Mechanisms (Graphical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Corioli's component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing.

Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, Determination of linear and angular velocity using instantaneous center method.

Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.

Module - 3

Velocity and Acceleration Analysis of Mechanisms (Analytical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method.

Freudenstein's equation for four bar mechanism and slider crank mechanism. **Function Generation** for four bar mechanism.

Module - 4

Spur Gears: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference,condition and expressions for minimum number of teeth to avoid interference.

Gear Trains: Simple gear trains, compound gear trains.

Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains.

Module - 5
Cams: Types of cams, types of followers. displacement, velocity and acceleration curves for uniform velocity, Simple Harmonic Motion, Uniform Acceleration, Retardation and Cycloidal motion. Cam profiles: disc cam with reciprocating followers such as knife-edge, roller and flat-face followers, inline and offset. **Analysis of Cams:** Analysis of arc cam with flat faced follower.
Course outcomes: **1. Identify mechanisms with basic understanding of motion.** **2. Comprehend motion analysis of planar mechanisms, gears, gear trains and cams.** **3. Carry out motion analysis of planar mechanisms, gears, gear trains and cams.**
TEXT BOOKS: 1. Rattan S.S, Theory of Machines,Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4th Edition, 2014. 2. Ambekar A. G., Mechanism and Machine Theory, PHI, 2009.
REFERENCE BOOKS Michael M Stanisic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis, Cengage Learning, 2016. 2. Sadhu Singh, **Theory of Machines,** Pearson Education (Singapore)Pvt. Ltd, Indian Branch New Delhi, 2nd Edi. 2006.

|| Jai Sri Gurudev ||

Adichunchanagiri Shikshana Trust (R)

BGS INSTITUTE OF TECHNOLOGY

Department of Mechanical Engineering

CO-PO & CO-PSO mapping (15 Scheme)

Course	Code	Subject	Credits	L-T-P	Assessment		Exam Duration
					SEE	CIE	
B.E	17ME42	KOM	04	3-2-0	100	40	3Hrs

CO'S

15C210.1	Identify mechanisms with basic understanding of motion.
15C210.2	Comprehend motion analysis of planar mechanisms, gears, gear trains and cams.
15C210.3	Carry out motion analysis of planar mechanisms, gears, gear trains and cams.

PO'S

PSO-1: Ability to acquire competencies in designing, analyzing and evaluating the mechanical components.

PSO-2: Ability to work professionally by applying manufacturing and management practices.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
15C210.1	3	2	1	-		-	-	-	-	-	-	1	3	2
15C210.2	3	3	2	1	-	-	-	-	-	-	-	1	3	3
15C210.3	3	3	2	1	-	-	-	-	-	-	-	1	3	3
AVG	3	2.66	1.66	0.66								1	3	2.66

Course Owner

HOD

Head of the Department
Department of Mechanical Engineering
BGSIT B G Nagar-571448

	60%	30%	10%	
	CIE	SEE	CES	TOTAL
CO1	1.69	0.06	2.33	1.26
CO2	0.55	0.06	2.46	0.59
CO3	1.65	0.06	2.44	1.25
CO4	0.00	0.00	0.00	0.00
CO5	0.00	0.06	0.00	0.00

Kinematics of machines	17ME42
Dr. Hemaraju	

CO-PO/PSO Mapping Table													
PO/PSO		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1
CO1		3	2	1									1	3
CO2		3	3	2	1								1	3
CO3		3	3	2	1								1	3
CO4														
CO5														
Sum		9	8		2		0	0	0		0		3	9
Number		3	3	3	2	0	0	0	0	0	0	0	3	3
Average		**3**	**2.666667**	**1.66**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	1	3
Weighted Sum		12.36	10.68	6.56	2.44								4.12	12.36
PO Attainment		**1.37**	**1.19**	**0.73**	**0.41**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.46**	**1.37**

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BGSIT	Lesson Plan & Execution	

Name of the Faculty	***Hemaraju***
Dept-Sem-Sec:	***ME-4-A***
Date of Commencement	***1 Feb 2019***
Last working day of Semester	***23 May 2019***
Source Material List	
1	Michael M Stanisic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis,Cengage Learning, 2016
2	Sadhu Singh, Theory of Machines, Pearson Education (Singapore)Pvt. Ltd, Indian Branch New Delhi, 2nd Edi. 2006
Course Outcome List	
1	Identify mechanisms with basic understanding of motion
2	Comprehend motion analysis of planar mechanisms, gears, gear trains and cams
3	Carry out motion analysis of planar mechanisms, gears, gear trains and cams
Subject Name	KINEMATICS OF MACHINES

Period	Planned			Execution		
	Date	Topic	Source material to be referred	Date	Topic	Source material to be referred
Module 1						
1	12 Feb 2019	Introduction: Definitions: Link, kinematic pairs, kinematic chain		12 Feb 2019	Introduction: Definitions: Link, kinematic pairs, kinematic chain	REF 1
2	13 Feb 2019	mechanism, structure, degrees of freedom		13 Feb 2019	mechanism, structure, degrees of freedom	REF 1 REF 2
3	14 Feb 2019	Classification links, Classifiction of pairs based on type of relative motion		14 Feb 2019	Classification links, Classifiction of pairs based on type of relative motion	REF 1
4	16 Feb 2019	Grubler's criterion, mobility of mechanism		16 Feb 2019	Grubler's criterion, mobility of mechanism	REF 1 REF 2
5	19 Feb 2019	Groshoff 's criteria, inversions of Grashoff 's chain		19 Feb 2019	Groshoff 's criteria, inversions of Grashoff 's chain	REF 1
6	20 Feb 2019	Mechanisms: Quick return motion mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism		20 Feb 2019	Mechanisms: Quick return motion mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism	REF 1 REF 2
7	21 Feb 2019	Oldham 's coupling, Straight line motion mechanisms Peaucellier's mechanism and Robert's mechanism		21 Feb 2019	Oldham 's coupling, Straight line motion mechanisms Peaucellier's mechanism and Robert's mechanism	REF 1 REF 2
8	23 Feb 2019	Intermittent Motion mechanisms:Geneva wheel mechanism, Ratchet and Pawl mechanism		23 Feb 2019	Intermittent Motion mechanisms:Geneva wheel mechanism, Ratchet and Pawl mechanism	REF 1 REF 2
9	26 Feb 2019	toggle mechanism, pantograph		26 Feb 2019	toggle mechanism, pantograph	REF 1
10	27 Feb 2019	condition for correct steering, Ackerman steering gear mechanism		27 Feb 2019	condition for correct steering, Ackerman steering gear mechanism	REF 1 REF 2
Module 2						
11	28 Feb 2019	Velocity and acceleration analysis of four bar mechanism		28 Feb 2019	Velocity and acceleration analysis of four bar mechanism	REF 1 REF 2

Period	Planned			Execution		
	Date	*Topic*	*Source material to be referred*	*Date*	*Topic*	*Source material to be referred*
12	2 Mar 2019	Velocity and acceleration analysis of four bar mechanism		2 Mar 2019	Velocity and acceleration analysis of four bar mechanism	REF 1 REF 2
13	5 Mar 2019	slider crank mechanism		5 Mar 2019	slider crank mechanism	REF 1 REF 2
14	6 Mar 2019	Mechanism illustrating Coriolis component of acceleration		6 Mar 2019	Mechanism illustrating Coriolis component of acceleration	REF 1
15	12 Mar 2019	Angular velocity and angular acceleration of links		12 Mar 2019	Angular velocity and angular acceleration of links	REF 1 REF 2
16	13 Mar 2019	velocity of rubbing		13 Mar 2019	velocity of rubbing	REF 1 REF 2
17	14 Mar 2019	Velocity Analysis by Instantaneous Center Method: Definition		14 Mar 2019	Velocity Analysis by Instantaneous Center Method: Definition	REF 1 REF 2
18	16 Mar 2019	Kennedy's theorem		16 Mar 2019	Kennedy's theorem	REF 1 REF 2
19	19 Mar 2019	Determination of linear and angular velocity using instantaneous center method		19 Mar 2019	Determination of linear and angular velocity using instantaneous center method	REF 1 REF 2
20	20 Mar 2019	Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism		20 Mar 2019	Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism	REF 1
Module 3						
21	21 Mar 2019	Velocity and acceleration analysis of four bar mechanism		21 Mar 2019	Velocity and acceleration analysis of four bar mechanism	REF 1
22	23 Mar 2019	Velocity and acceleration analysis of four bar mechanism		23 Mar 2019	Velocity and acceleration analysis of four bar mechanism	REF 1
23	26 Mar 2019	Velocity and acceleration analysis of four bar mechanism		26 Mar 2019	Velocity and acceleration analysis of four bar mechanism	REF 1
24	27 Mar 2019	slider crank mechanism using complex algebra method		27 Mar 2019	slider crank mechanism using complex algebra method	REF 1

Period	Planned			Execution		
	Date	*Topic*	*Source material to be referred*	*Date*	*Topic*	*Source material to be referred*
25	28 Mar 2019	slider crank mechanism using complex algebra method		28 Mar 2019	slider crank mechanism using complex algebra method	REF 1 REF 2
26	30 Mar 2019	slider crank mechanism using complex algebra method		30 Mar 2019	slider crank mechanism using complex algebra method	REF 2
27	2 Apr 2019	Freudenstein 's equation for four bar mechanism and slider crank mechanism		2 Apr 2019	Freudenstein 's equation for four bar mechanism and slider crank mechanism	REF 1
28	3 Apr 2019	Freudenstein 's equation for four bar mechanism and slider crank mechanism		3 Apr 2019	Freudenstein 's equation for four bar mechanism and slider crank mechanism	REF 1
29	4 Apr 2019	Function Generation for four bar mechanism		4 Apr 2019	Function Generation for four bar mechanism	REF 1
30	9 Apr 2019	Function Generation for four bar mechanism		9 Apr 2019	Function Generation for four bar mechanism	REF 1
Module 4						
31	10 Apr 2019	Gear terminology, law of gearing		10 Apr 2019	Gear terminology, law of gearing	REF 2
32	16 Apr 2019	path of contact, arc of contact		16 Apr 2019	path of contact, arc of contact	REF 1
33	18 Apr 2019	contact ratio of spur gear, Interference in involute gears		18 Apr 2019	contact ratio ofspur gear, Interference in involute gears	REF 1
34	20 Apr 2019	methods of avoiding interference, back lash		20 Apr 2019	methods of avoiding interference, back lash	REF 1
35	23 Apr 2019	condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact		23 Apr 2019	condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact	REF 2
36	24 Apr 2019	Gear Trains: Simple gear trains		24 Apr 2019	Gear Trains: Simple gear trains	REF 1
37	25 Apr 2019	Gear Trains: Simple gear trains		25 Apr 2019	Gear Trains: Simple gear trains	REF 1
38	27 Apr 2019	compound gear trains		27 Apr 2019	compound gear trains	REF 1
39	30 Apr 2019	Epicyclic gear trains:aAlgebraic and tabular methods of finding velocity ratio of epicyclic gear trains		30 Apr 2019	Epicyclic gear trains:aAlgebraic andtabular methods of finding velocity ratio of epicyclic gear trains	

Period	Planned			Execution		
	Date	*Topic*	*Source material to be referred*	*Date*	*Topic*	*Source material to be referred*
40	2 May 2019	torque calculation in epicyclic gear trains		2 May 2019	torque calculation in epicyclic gear trains	
Module 5						
41	4 May 2019	Cams: Types of cams, types of followers		4 May 2019	Cams: Types of cams, types of followers	
42	8 May 2019	displacement, velocity and acceleration curves for uniform velocity		8 May 2019	displacement, velocity and acceleration curves for uniform velocity	
43	9 May 2019	Simple Harmonic Motion, Uniform Acceleration Retradation		9 May 2019	Simple Harmonic Motion, Uniform Acceleration Retradation	
44	11 May 2019	Cycloidal motion, Cam profiles: disc cam with reciprocating / oscillating follower having knife-edge		11 May 2019	Cycloidal motion, Cam profiles: disc cam with reciprocating / oscillating follower having knife-edge	
45	14 May 2019	roller and flat-face follower inline and offset		14 May 2019	roller and flat-face follower inline and offset	
46	15 May 2019	Analysis of arc cam with flat faced follower		15 May 2019	Analysis of arc cam with flat faced follower	
47	21 May 2019	Analysis of arc cam with flat faced follower		21 May 2019	Analysis of arc cam with flat faced follower	
48	22 May 2019	Analysis of arc cam with flat faced follower		22 May 2019	Analysis of arc cam with flat faced follower	
49	23 May 2019	Analysis of arc cam with flat faced follower		23 May 2019	Analysis of arc cam with flat faced follower	
50	23 May 2019	Analysis of arc cam with flat faced follower		23 May 2019	Analysis of arc cam with flat faced follower	

Module No.	# of Classes Planned(till date)	Planned Effort(till date)	# of Classes Executed(till date)	Actual Effort (till date)	% Coverage
1	10	9hrs 10min	10	9hrs 10min	100.0
2	10	9hrs 10min	10	9hrs 10min	100.0
3	10	9hrs 10min	10	9hrs 10min	100.0
4	10	9hrs 10min	10	9hrs 10min	100.0
5	10	9hrs 10min	10	9hrs 10min	100.0

Faculty in charge

HOD's Signature

Head of the Department
Department of Mechanical Engineering
BGSIT B G Nagar-571448

Signature of Principal (&remark if any)

MECHANISMS WITH LOWER PAIRS

I. PANTOGRAPH :-

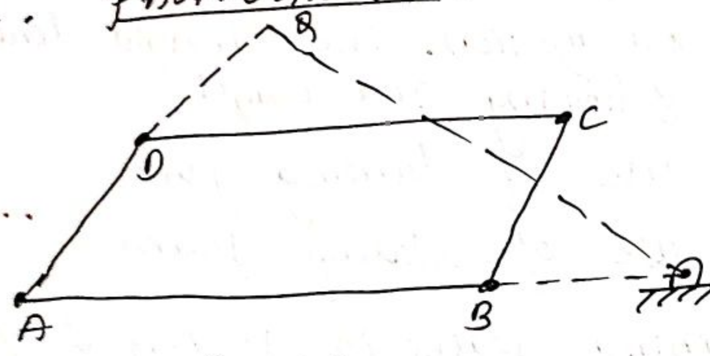


fig. 2.1

A Pantograph is an instrument used to reproduce the drawings of different Scales. It is a mechanism with lower pairs used to trace the Path to an Enlarged Scale or a reduced Scale as required. one type of Pantograph is shown in fig 2.1. It consists of four links AB, BC, CD and DA which are Pin Jointed at A, B, C and D So that ABCD is a parallelogram. The link AB is Extended to the fixed Pin O. The Point P on link BC and the point Q on the Extension of link AD are Jointed to Point O through a straight line. It can be shown that point Q reproduces the motion of point P on Enlarged Scale or it can be stated that point P reproduces the motion of Point Q on a reduced scale. The triangles OPB and OQA are similiar so that

$$\frac{OP}{OQ} = \frac{OB}{OA} = \frac{BP}{AQ} \quad \text{—— (i)}$$

The whole System is pivoted at O. Equation (i) is true for all positions of the mechanisms P and Q traces similar paths and displacements of P and Q are parallel. It can also be shown that displacements of P and Q are in the proportion OB : OA

A Pantograph is used as an indicator rig in order to reproduce to a small scale the displacement of the C/S head and so the Piston of reciprocating steam Engine. Pantographs may be used for Cutting tools, reproduction of plane areas, figures Etc

STRAIGHT LINE MOTIONS

~~The Straight~~ There is a point on the mechanism which traces a straight path within the possible limits of motion. The straight line motion may be given in the following two ways:

(a) By the use of turning pairs

(b) By the use of sliding pairn

The use of turning pairs in preferred for straight line motion because of more wear and bulky size of sliding pairs

Condition for Exact Straight line motion

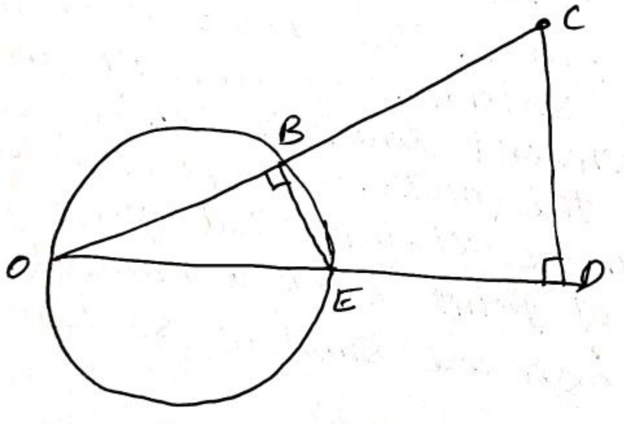


fig 2.2

By reffering fig 2.2, let O be a point on the circumference of a circle of diameter OE. Let any cord OB in extended upto point C, such that

$$OB \cdot OC = \text{Constant}$$

Then the path of point C will be a straight line perpendicular to the diameter OE of the circle along the circumference of which point B moves. Extend OE to point D such that CD is perpendicular to OD. Join BE.

The triangles OBE and OCD are similar because angle BOE is common and angles OBE = angle CDO = right angle

So $$\frac{OB}{OE} = \frac{OD}{OC}$$ OE = dia of circle, constant

$$OD = \frac{OB}{OE} \cdot OC$$ OB.OC = Constant as assumed.

So OD will be constant as per Eqn (i). Hence point C moves along the straight path CD which is perpendicular to the Exact straight line motion mechanisms with turning pairs as described peaucellier mechanism:

Peaucellier mechanism

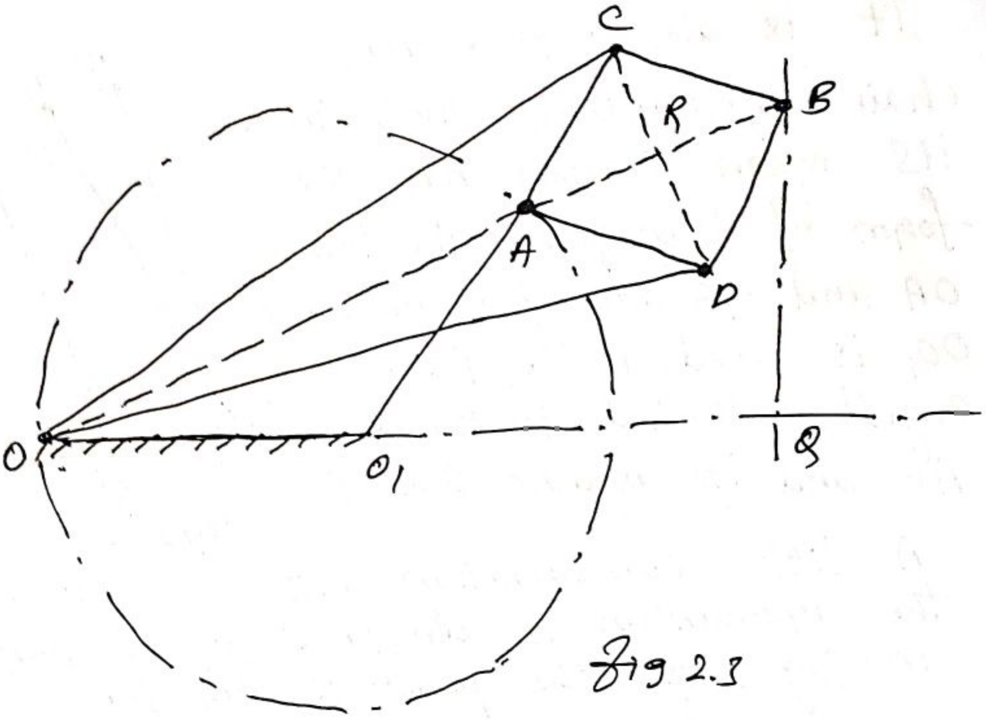


fig 2.3

It Consists of fixed link OO_1 and the Straight links O_1A, OC, OD, AD, DB, BC and CA are Connected by turning pairs at their intersections, as shown in fig 2.3
The pin at A is constrained to move along the circum-ference of a circle with the fixed diameter OP, by means of the link O_1A. From fig 2.3

$$AC = CB = BD = DA \; ; \; OC = OD \text{ and } OO_1 = O_1A$$

It may proved that the product $OA \times OB$ remains Constant, when the link O_1A rotates. Join CD to bisect AB at R. Now from right angled triangles ORC and BRC, we have

$$OC^2 = OR^2 + RC^2 \quad \text{---(i)}$$

$$BC^2 = RB^2 + RC^2 \quad \text{---(ii)}$$

(i) − (ii) gives

$$OC^2 - BC^2 = OR^2 - RB^2$$

$$= (OR+RB)(OR-RB)$$

$$= OR \times OA$$

Since OC and BC are of Constant length, therefore Product $OB \times OA$ remains Constant. Hence Point B traces a Straight Path $\perp^r$ to the diameter OP.

Scanned with CamScanner

Roberts Mechanism

It is also a four bar chain mechanism, which, in its mean position, has the form of trapezium. The links OA and O_1B are of equal length OO_1 is fixed. A bar PQ is rigidly attached to the link AB and its middle point P

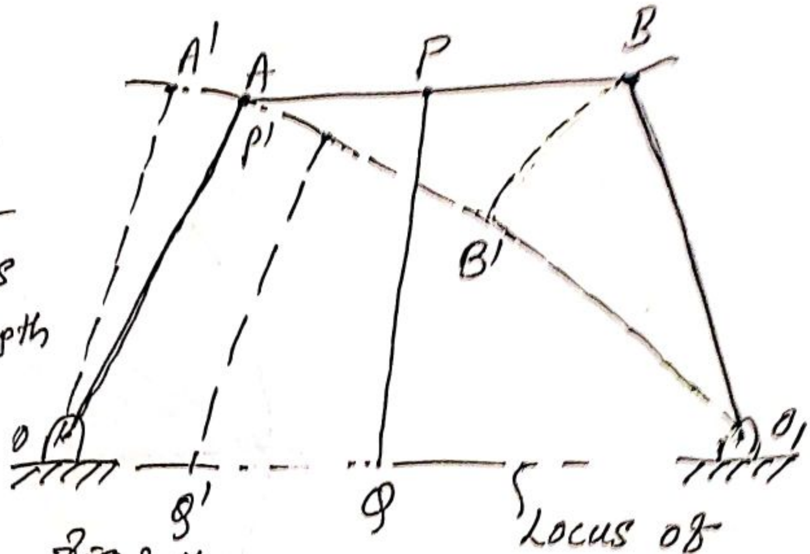


fig 2.4

A little consideration will show that if the mechanism is displaced as shown by the dotted lines in fig 2.4, the point Q will trace out an approximatily straight line.

INTERMITTENT MOTION MECHANISMS

(i) Ratchet & Pawl mechanism

This mechanism is used in producing intermittent rotary motion from an oscillating or reciprocating motion member. A ratchet & pawl mechanism consists of ratchet wheel 2 and a pawl 3 as shown in fig 2.5. When the lever 4 carrying pawl in raised, the ratchet wheel rotates in counter clockwise direction (driven by pawl). As the pawl lever is lowered the pawl slides over the ratchet teeth. One more pawl 5 is used to prevent the ratchet from reversing. Ratchets are used in feed mechanisms, lifting jacks, clocks, watches & counting devices

Geneva Mechanism:- Geneva Mechanism is intermittent motion Mechanism. It consists of a driving wheel D carrying a pin P which Engages in a slot of the follower F as shown in fig 2.46. During the quarter revolution of the rotating, the pin & follower remain in contact & hence the follower is turned by one quarter turn. During the remaining time of one revolution of driver, the follower remains at rest locked in position by the circular arc. This mechanism used in preventing overwinding of main springs in clocks and watches, feeding of film roll in Early motion picture projectors and indexing of a worktable on a m/c tool. For the motion to be free from shock the slot must be tangential to the path of the pin upon management. Locking plate in provided to lock the follower when it in not being indexed.

Automobile Steering gear mechanisms.

The relative motion between the wheels of the vehicle and the road surface should be pure rolling one.

In order to satisfy this condition when the vehicle is moving a along a curved path, the steering gear must be so designed that the paths of contact of each wheel with the ground are concentric circular arcs. Steering ~~gear~~ is usually effected by turning the axes of rotation of the two front wheels relative to the chassis or body of the vehicle, and to satisfy the above condition, the axis of the wheel on the inside of the curve must be turned through a larger ~~angle~~ angle than the axis of the wheel on the outside of the curve.

The front wheels are mounted on the short separate axles which are ~~Provided~~ pivoted to the chassis of the car.

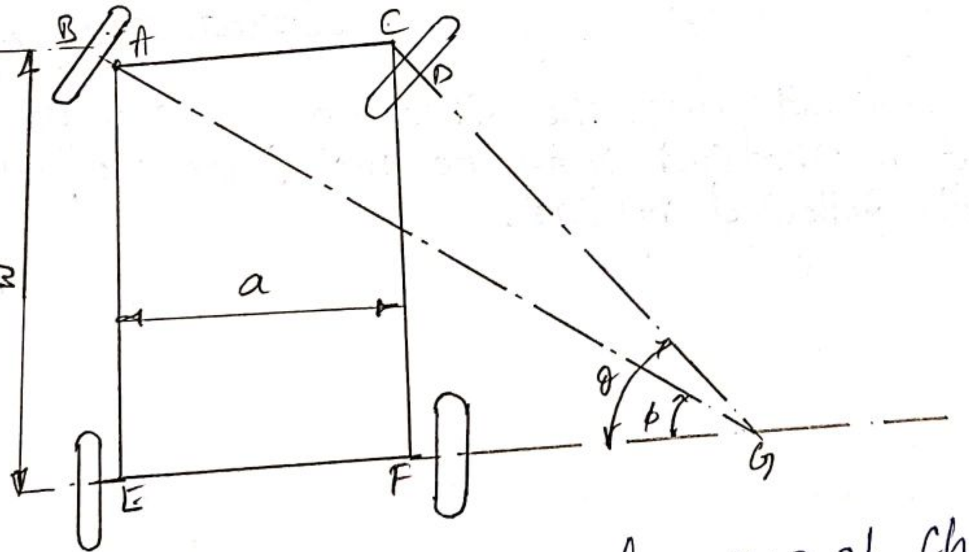


fig shows the plan view of chassis and wheels. From fig AB and CD intersect the common axis EF of the rear wheels at the point G, so that the path of contact of each wheel with the ground is circular arc with centre G.

from fig $AC = EF = EG - FG$ — (1)

$$\tan\theta = \frac{CF}{FG}$$

$$\therefore FG = \frac{CF}{\tan\theta} = CF\cot\theta \quad \text{— (a)}$$

$$\tan\phi = \frac{AE}{EG}$$

$$\therefore EG = \frac{AE}{\tan\phi} = AE\cot\phi \quad \text{— (b)}$$

from (a) & (b) $\therefore AC = AE\cot\phi - CF\cot\theta$ $\quad (\because AE = CF)$

$$= AE\cot\phi - AE\cot\theta$$

$$= AE(\cot\phi - \cot\theta)$$

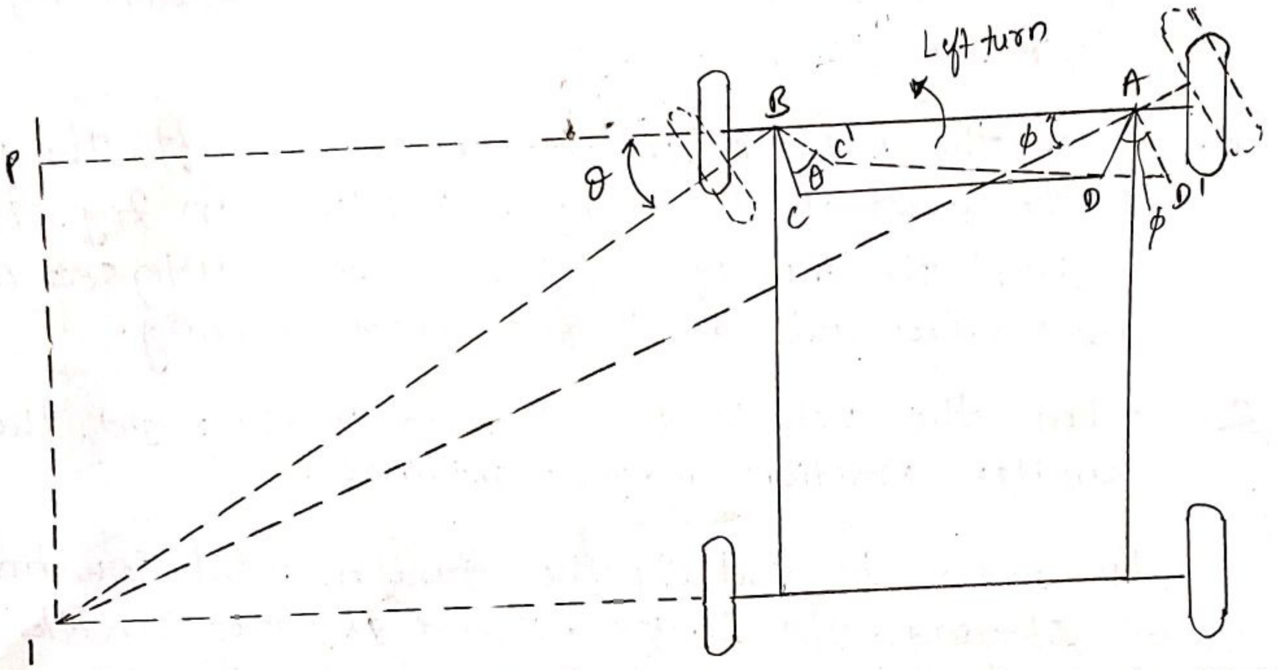
$$\therefore \cot\phi - \cot\theta = \frac{AC}{AE} = \frac{a}{w}$$

i,e $\cot\phi - \cot\theta = \frac{a}{w}$ = Condition for Correct Steering.

So for Correct Steering, the Steering gear must obey this Equation whatever may be the radius of curvature of the Path followed by car.

Ackerman Steering gear mechanism

This mechanism is made of only turning pairs and is based on 4-bar mechanism.



The Ackerman steering gear mechanism is much simpler than Davis gear. The difference between the Ackerman and Davis Steering gears are

1. The whole mechanism of the Ackerman steering gear is on back of the front wheels; whereas in Davis steering gear, it is in front of the wheels.
2. The Ackerman Steering gear consists of turning pairs whereas Davis Steering gear consists of sliding members.

In Ackerman Steering gear, the mechanism ABCD is a four bar chain as shown in fig. The shorter links BC and AD are of Equal length and are connected by hinge points with front wheel axels. The longer links AB and CD are of unequal length. The following are the only three Position for Corret Steering.

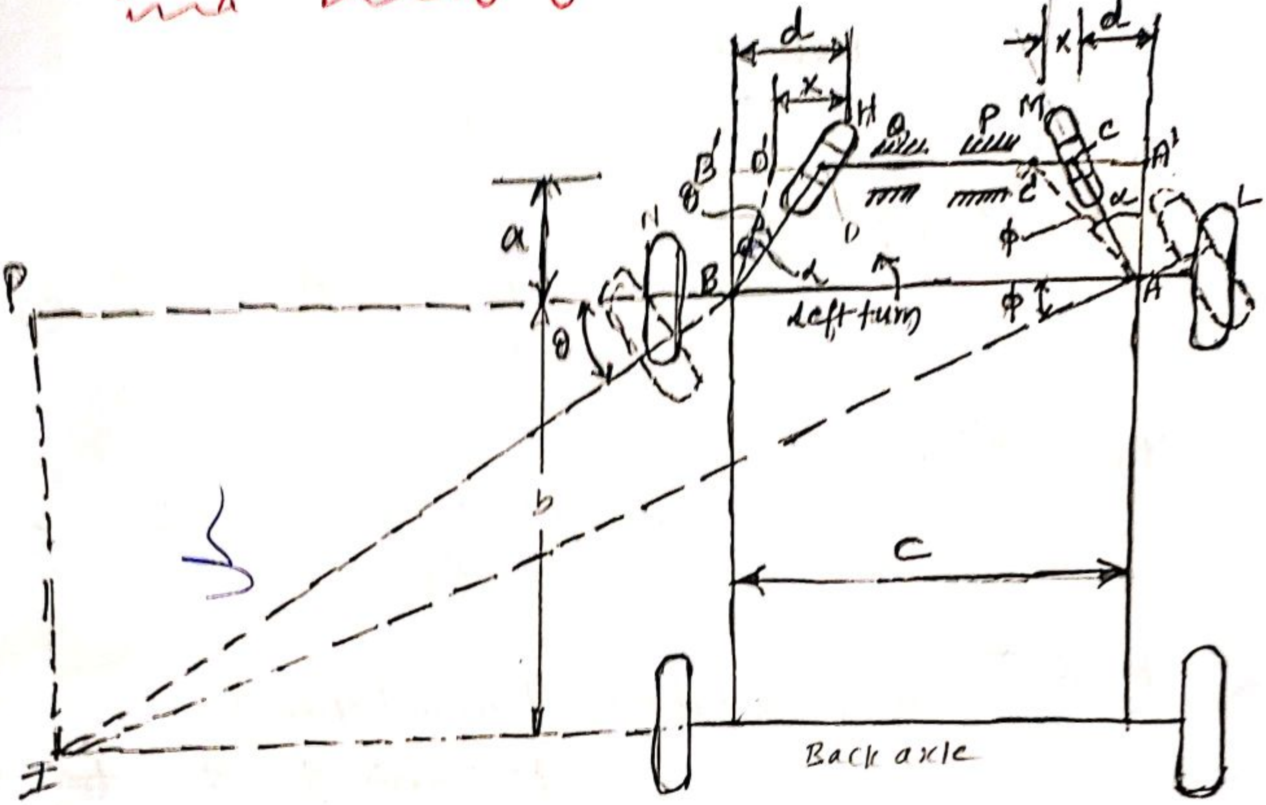
1. When the vehicle moves along straight path, the longer links AB and CD are parallel and the shorter links BC and AD are inclined to the longitudinal axis of the vehicle, as shown by firm lines as shown in fig.

2. When the vehicle is steering to the left, the position of the gear is shown by dotted lines in fig. In this position, the lines of front wheel axle intersect on the back wheel axle at I, for correct steering.

3. When the vehicle is steering to the right, the similar position may be obtained.

In order to satisfy the fundamental equation for correct steering, the links AD and DC are correctly proportioned. The value of θ and ϕ may be obtained either graphically or by calculation.

Davis Steering gear



The Davis Steering gear is Shown in fig.
It is an Exact steering gear mechanism. The slotted links AM and BH are attached to the front wheel axle, which turn on pivots A & B respectively. The rod CD is constrained to move in the direction of its length, by the sliding members at P & Q. These constraints are connected to the slotted link "AM" and "BH" by a sliding and a turning pair at each end. The steering is affected by moving CD to right or left of its normal position. C'D' shows the position of "CD" for turning to the left

a = Vertical distance b/n AB and CD

b = wheel base

d = Horizontal distance b/n AC and BD

c = distance b/n the pivots A and B of the front axle

x = Distance moved by AC to AC' = CC' = DD'

α = Angle of inclination of the links AC and BD to the vertical

From Δ^{le} $AA'C'$

$$\tan(\alpha+\phi) = \frac{A'C'}{AA'} = \frac{d+x}{a} \quad \text{— (i)}$$

from Δ^{le} $AA'C$ $\quad \tan\alpha = \frac{A'C}{AA'} = \frac{d}{a} \quad \text{— (ii)}$

From Δ^{le} $BB'D'$ $\quad \tan(\alpha-\theta) = \frac{B'D'}{BB'} = \frac{d-x}{a} \quad \text{— (iii)}$

W.K.T $\quad \tan(\alpha+\phi) = \frac{\tan\alpha+\tan\phi}{1-\tan\alpha.\tan\phi}$ from Eqn (i) & (ii)

or $\quad \frac{d+x}{a} = \frac{d/a+\tan\phi}{1-d/a\cdot\tan\phi} = \frac{d/a+a\tan\phi}{a-d/a\tan\phi}$

$$\frac{d+x}{a} = \frac{d+a\tan\phi}{a-d\tan\phi}$$

$$(d+x)(a-d\tan\phi) = a(d+a\tan\phi)$$

$$ad - d^2\tan\phi + ax - dx\tan\phi = ad + a^2\tan\phi$$

$$ax = a^2\tan\phi + d^2\tan\phi + dx\tan\phi$$

$$ax = \tan\phi(a^2+d^2+dx)$$

$$\tan\phi = \frac{ax}{a^2+d^2+dx} \quad \text{— (IV)}$$

III^{ly} from $\tan(\alpha-\theta) = \frac{d-x}{a}$ we get

$$\tan\theta = \frac{a.x}{a^2+d^2-dx} \quad \text{— (V)}$$

We know that for correct steering

$$\cot\phi - \cot\theta = \frac{a}{w}$$

or $$\frac{1}{\tan\phi} - \frac{1}{\tan\theta} = \frac{a}{w}$$

$$\frac{a^2+d^2+dx}{ax} - \frac{a^2+d^2-dx}{ax} = \frac{a}{w}$$

$$\frac{a^2+d^2-a^2-d^2+dx+dx}{ax} = \frac{a}{w}$$

$$= \frac{2dx}{ax} = \frac{a}{w} \quad \text{or} \quad \frac{2d}{a} = \frac{a}{w}$$

$$2\tan\alpha = \frac{a}{w} \quad (\because d/a = \tan\alpha)$$

or $$\boxed{\tan\alpha = \frac{a}{2w}}$$

Note:- Though the gear is theoritically correct, but due to the presence of more sliding members, the wear will be increased which produces slackness b/n the sliding surfaces, thus eliminating the original accuracy. Hence Davis steering gear is not in common use.

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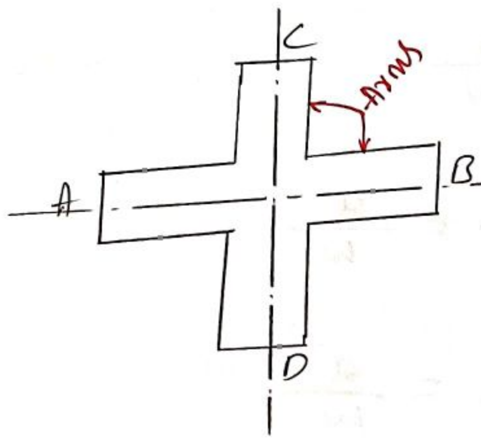
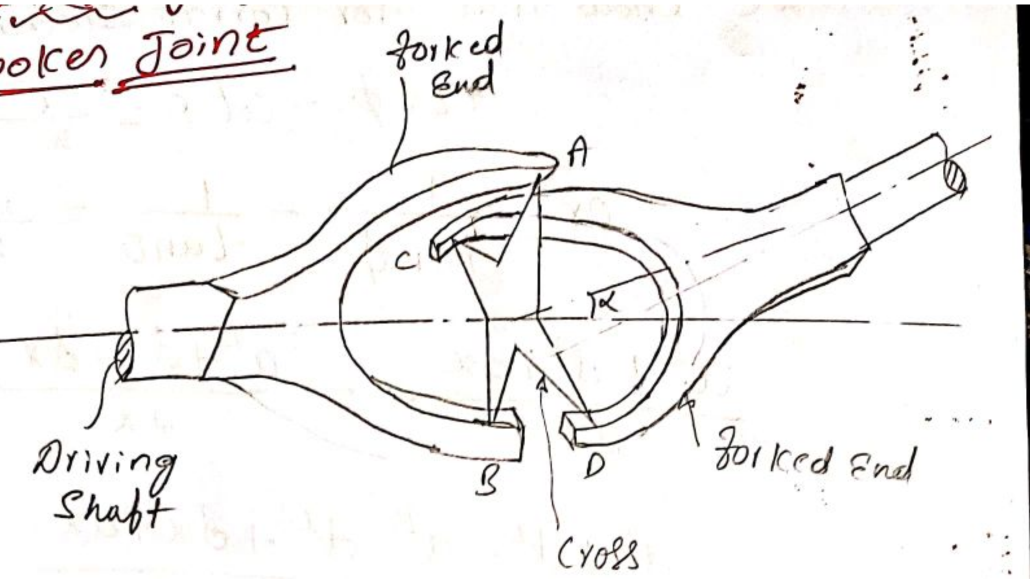
Universal or Hooken Joint





A Hooken Joint is used to connect two Shafts, which are intersecting at a Small angle, as Shown in fig. The End of Each Shaft is forked to U-type and Each fork provides two bearings for the arms of a cross. The arms of the Cross are perpendicular to Each other. The motion is transmitted from the driving shaft to driven Shaft through a cross. The inclination of the two shafts may be constant, but in actual practice it varies, when the motion is transmitted. The main application of the Universal or Hooken Joint is found in the transmission of the gear box to the differential or back axle of the automobiles. It is also used for transmission of power to different Spindles of multiple drilling machine. It is also used as a Knee Joint in milling machines.

Note:- invented by English physicist and mathematician "Robert Hooke" who first applied it to connect two offset Misaligned shafts.

(20 Marks)

BGSIT BG Nagara	**Doc. Title: Internal Test Question Paper**	**Doc. No.: 06#Form#02b**
	Page 1 of 1 / **Date: 07.03.2019**	**Rev. No. 00**

Internal Test Question Paper Format – CBCS Scheme (VTU)

Name of the Faculty/s:

Date: Signature:

Reviewer's Signature:

NOTE: Only the following information is to be given to the students.

BGS Institute of Technology

Department: Mechanical Engineering

Test: I

USN:

Semester: VI

Subject Name & Code: KINEMATICS OF MACHINES(17ME42)

Instructions

Duration: 60 minutes

Max. Marks: 30

i) Select one question from each part.

ii) All questions carry equal marks.

Question Number	Questions	Marks	CO	Levels
	PART - A			
1	a) Determine the mobility (degrees of freedom) of the mechanism shown in Fig.1.a	04	CO1	L1
	b) What is a machine ? Giving example, differentiate between a machine and a structure	05	CO1	L1
	c) Explain the terms : i Lower pair, ii Higher pair, iii Kinematic chain, iv. Inversion.	06	CO1	L1
	OR			
2	a) State and prove Grashoff criteria	05	CO1	L1
	b) Enumerate three inversions of Grasshoff chain	10	CO1	L1
	PART - B			
3	**a)** Sketch a pantograph, explain its working and show that it can be used to reproduce to an enlarged scale a given figure	07	CO1	L2
	b) What are straight line mechanisms ? Describe one type of exact straight line motion mechanism with the help of a sketch.	08	CO1	L2
	OR			
4	**a)** What is the condition for correct steering ? Sketch and show any one main type of steering gear and discuss their relative advantages.	07	CO1	L1
	b) Sketch an intermittent motion mechanism and explain its practical applications.	08	CO1	L1

Verified

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Department of Mechanical Engineering
BGSIT B G Nagar-571448

CBCS Scheme (ACU)

DEPARTMENT: MECHANICAL ENGINEERING

Scheme & Solution – Date:

Semester: 4 Subject Title: KOM Subject Code: 17ME42

Question Number	Solution	Marks Allocated
	Part A	
1	(a) $DOF = 3(n-1) - 2j_1 - j_2$ —	03
	terms —	01
	(b) Difference b/n Structure & Machine —	05
	(c) Terms & Explanations —	06
		15
	Or	
2	(a) Grashoff's law statement —	02
	Proof = $s+l < p+q$ —	03
	(b) Inversion of Grashoff's chain (03+03+04) — ① ② ③	10
		15
	Part B	
3	(a) Pantograph — Sketch —	03
	— Explanation —	04
	(b) Listing of St line motion mechanism	03
	Any one type St line motion mechanism —	05
		15

Question Number	Solution	Marks Allocated
(4)	(a) * Condition for corrat steering —	03
	(b) * Advantages & disadvantages —	02
	(c) * Any one type of steering gear mechanism	02
		07
	(b) Intermittent motion mechanism —	03
	Sketch – 02 Expln – 01	03
	Practical application	02
		08

Internal Test Question Paper Format – CBCS Scheme (VTU)

Name of the Faculty/s:

Date: Signature:

Reviewer's Signature:	

NOTE: Only the following information is to be given to the students.

BGS Institute of Technology

Department: Mechanical Engineering

Test: 2

USN:

Semester: IV **Section:** A

Subject Name & Code: KOM (17ME42)

Instructions

Duration: 60 minutes Max. Marks: 30

i) Select one question from each part.

ii) All questions carry equal marks.

Question Number	Questions	Marks	CO	Levels
	PART - A			
1	Draw a cam profile to drive an oscillating roller follower to the specifications given below : Follower to move outwards through an angular displacement of 20° during the first 120° rotation of the cam ; Follower to return to its initial position during next 120° rotation of the cam ; Follower to dwell during the next 120° of cam rotation. The distance between pivot centre and roller centre = 120 mm ; distance between pivot centre and cam axis = 130 mm ; minimum radius of cam = 40 mm ; radius of roller = 10 mm ; inward and outward strokes take place with simple harmonic motion.	15	CO2	L4
	OR			
2	Explain the terms : Module, Pressure angle, and Addendum. State and prove the law of gearing. Show that involute profile satisfies the conditions for correct gearing. Derive an expression for the velocity of sliding between a pair of involute teeth.	15	CO2	L4
	PART - B			
3	Explain with sketches the different types of cams and followers. Design a cam for operating the exhaust valve of an oil engine. It is required to give equal uniform acceleration and retardation during opening and closing of the valve each of which corresponds to 60° of cam rotation. The valve must remain in the fully open position for 20° of cam rotation. The lift of the valve is 37.5 mm and the least radius of the cam is 40 mm. The follower is provided with a roller of radius 20 mm and its line of stroke passes through the axis of the cam.	15	CO2	L4
	OR			
4	Explain construction of Involute profile and cycloidal profile with neat sketch. Compare between them. Also explain advantages and disadvantages of Involute and cycloidal profile	15	CO2	L4

CBCS Scheme (ACU)

DEPARTMENT: MECHANICAL ENGINEERING

Scheme & Solution – Date:

Semester: 4 Subject Title: KOM Subject Code: 17ME42

Question Number	Solution	Marks Allocated
1.	Displacement diagram →	04
	CAM Profile →	11
		15
2.	Defns (i) Module — 01, (ii) Pressure angle — 01, (iii) Addendum — 01	03
	$\frac{\omega_1}{\omega_2} = \frac{O_2M}{O_1N} = \frac{O_2P}{O_1P}$ — 02; Proof with sketch. 03	05
	Involute profile — Condn of gearing — 02	02
	Velocity of sliding $\frac{\omega_1}{\omega_2} = \frac{O_2P}{O_1P} = \frac{PN}{MP}$ Proof	05
		5+2+5+3 = 15
3.	Displacement diagram — 03	3+7 = 10
	Cam profile — 07	
	Cam followers with neat sketches — 05	05
		15

06#Form#03-0

Question Number	Solution	Marks Allocated
4.	Comparision of Involute & cycloidal profile ———	05
	Construction of Involute & cycloidal profile ———	05
	Advantages & disadvantages of Involute & cycloidal ———	05
		15

06#Form#03-0

BGS Institute of Technology

Department: Mechanical Engineering

Test: III

Semester: VI

Subject Name & Code: KOM (17ME42)

Instructions

Duration:60minutes

Max. Marks: 30

i) Select one question from each part.

ii) All questions carry equal marks.

Question Number	Questions	Marks	CO	Levels
	PART - A			
1	a) Derive an expression for the minimum number of teeth required on the pinion in order to avoid interference in involute gear teeth when it meshes with wheel.	08	CO2	L4
	b) A 20° involute pinion with 20 teeth drives a gear having 60 teeth. Module is 8 mm and addendum of each gear is 10 mm. 1. State whether interference occurs or not. Give reasons. 2. Find the length of path of approach and arc of approach if pinion is the driver	07	CO2	L4
	OR			
2	Two mating involute spur gear of 20° pressure angle have a gear ratio of 2. The number of teeth on the pinion is 20 and its speed is 250 r.p.m. The module pitch of the teeth is 12 mm. If the addendum on each wheel is such that the path of approach and the path of recess on each side are half the maximum possible length, find : 1. the addendum for pinion and gear wheel ; 2. the length of the arc of contact ; and 3. the maximum velocity of sliding during approach and recess. Assume pinion to be the driver.	15	CO2	L4
	PART - B			
3	The following data relate to a pair of 20° involute gears in mesh : Module = 6 mm, Number of teeth on pinion = 17, Number of teeth on gear = 49 ; Addenda on pinion and gear wheel = 1 module. Find : 1. The number of pairs of teeth in contact ; 2. The angle turned through by the pinion and the gear wheel when one pair of teeth is in contact, and 3. The ratio of sliding to rolling motion when the tip of a tooth on the larger wheel (i) is just making contact, (ii) is just leaving contact with its mating tooth, and (iii) is at the pitch point	15	CO2	L4
	OR			
4	A mechanism, as shown in Fig.4, has the following dimensions: OA = 200 mm; AB = 1.5 m; BC = 600 mm; CD = 500 mm and BE = 400 mm. Locate all the instantaneous centres. If crank OA rotates uniformly at 120 r.p.m. clockwise, find 1. the velocity of B, C and D, 2. The angular velocity of the links AB, BC and CD.	15	CO2	L4

Signature of Staff

Signature of HOD

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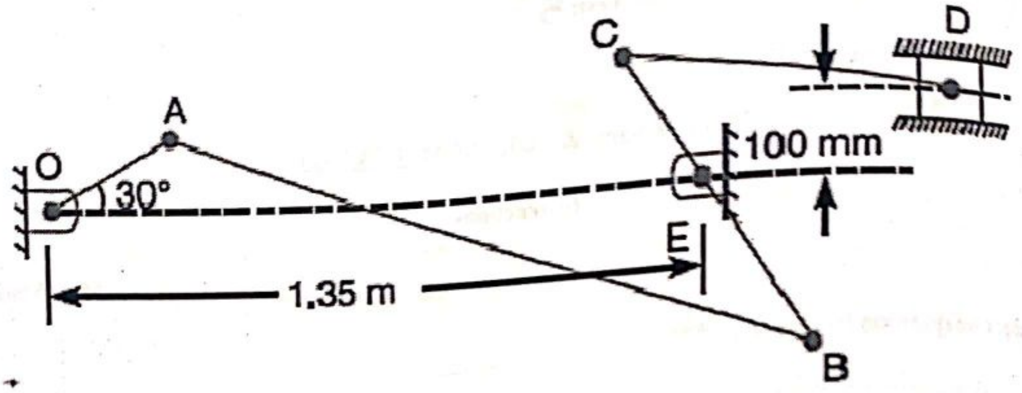

1. (a)

Fig.4

Scheme of Evaluation

Sub KOM   Test - 2   Date of test:-

1. (a) Derivation of

$$t = \frac{2 A_p}{\sqrt{1 + G(G+2)\sin^2\phi} - 1}$$ — 08 marks

(b) $t \nless t_p$ Interference does not occurs —— 04

POa = 25.8 mm —— 03

POR = 27.45 mm —— 02

07

2 (i) A_p = 19.5 mm, A_g = 7.8 mm —— 04

(ii) ∠AC — 65.5 mm —— 05

(iii) $V_{s\,max\,i}$ — 807.5 mm/s — 03

(iv) $V_{s\,max\,ii}$ — 1615 mm/s —— 03

15

3 (i) C.R = 1.692 —— 03

(ii) θ_p = 34.62 —— 04

θ_g = 12° —— 04

(iii) $\frac{V_s}{N_R}$ = 0.41 —— 04

15

4. Sketch —— 02

V_B = 3.2 m/s, V_C = 1.6 m/s —— 04

ω_{AB} = 2.99 r/s — 3

ω_{BC} = 8 r/s — 3

ω_{CD} = 2.16 r/s — 3

09

2+4+9 = 15

||Jai Sri Gurudev||

Sri Adichunchanagiri Shikshana Trust (R.)

BGS INSTITUTE OF TECHNOLOGY, BG Nagara

Department of Mechanical Engineering

Assignment-1

		Cos	Levels	Marks
1	Explain(i) Kinematic Pair (ii) Types of Links (iii) Grashoffs criterion	1	1	5
2	Explain with neat sketches Ratchet and Pawl mechanism & Toggle mechanism	1	1	5
3	Prove that Peaucelliers mechanism traces exact straight line motion. Also Explain mechanism with neat sketch.	1	1	5
4	Sketch and explain following mechanisms. (i) Ackerman steering mechanism. (ii) Pantograph (iii) Drag Link Mechanism	1	1	5
5	A cam operating a knife-edged follower has the following data : (*a*) Follower moves outwards through 30 mm during 120° of cam rotation. (*b*) Follower dwells for the next 60°. (*c*) Follower returns to its original position during next 90°. (*d*) Follower dwells for the rest of the rotation. The displacement of the follower is to take place with simple harmonic motion during both the outward and return strokes. The least radius of the cam is 50 mm. Draw the profile of the cam when the axis of the follower passes through the cam axis, and 2. the axis of the follower is offset 10	1	3	5

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Assignment-2

		Cos	Levels	Marks
1	Draw a cam to the specifications given below : (a) Minimum radius of the cam = 20 mm., Rotation counterclockwise at 1000 rpm with an outward stroke UARM 120° (b) Follower to return to its initial position during next 120° rotation of the cam with SHM ; (c) Follower to dwell during the next 60° of cam rotation. The distance between pivot centre and roller centre = 5 mm Lift of the the follower = 20 mm	3	3	5
2	Construct the profile of a cam to suit the following specifications : Cam shaft diameter = 40 mm ; Least radius of cam = 25 mm ; Diameter of roller = 25 mm; Angle of lift = 120° ; Angle of fall = 150° ; Lift of the follower = 40 mm ; Number of pauses are two of equal interval between motions. During the lift, the motion is S.H.M. During the fall the motion is uniform acceleration and deceleration. The speed of the cam shaft is uniform. The line of stroke of the follower is off-set 12.5 mm from the centre of the cam.	3	3	5
3	A cam rotating clockwise with a uniform speed of 300 rpm is to give the roller follower of 10 mm diameter with the following motion : (*a*) Follower to move outwards through a distance of 30 mm during 120° of cam rotation ; (*b*) Follower to dwell for 30° of cam rotation ; (*c*) Follower to return to its initial position during 120° of cam rotation ; and (*d*) Follower to dwell for the remaining 90° of cam rotation. The minimum radius of the cam is 25 mm and the line of stroke of the follower is offset 10 mm from the axis of the cam and the displacement of the follower is to take place with simple harmonic motion on both the outward and return strokes. Draw the cam profile.	3	3	5
4	Draw the profile of the cam operating a rocker reciprocating follower and with the following data. Minimum radius of the cam = 25 mm , lift = 30 mm, roller diameter = 15 mm. then the follower lowers during 150^0 of the cam rotation with UARm rotation followed by dwell period. Then the cam rotates at a uniform speed of 150 rpm (cw). The axis of the follower passes through the axis of the camshaft. Calculate velocity and acceleration	1	3	5
5	Draw the profile of the cam operating a roller follower with following data. Minimum radius of the = 25 mm, lift of the follower = 30 mm. roller diameter = 15 mm. angle of descent with uniform acceleration and deceleration = 150^0. Angle of ascent with 150 rpm $=120^0$. Dwell between ascent and descent = 30^0. If the cam rotates at a uniform speed of 150 rpm.	1	3	5

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Assignment-3

		Cos	Levels	Marks
1	Two mating spur gears with module of 6.5 mm have 19 and 47 teeth of 20^0 pressure angle and 65 mm addendum. Determine the number of pairs of teeth is in contact. Also determine the sliding velocity at the instant (i) during engagement (ii) while engagement terminates. The pitch line velocity is 1.2 m/s.	3	3	5
2	The number of teeth on each of the two equal spur gears in mesh are 40. The teeth have 20° involute profile and the module is 6 mm. If the arc of contact is 1.75 times the circular pitch, find the addendum.	3	3	5
3	A pair of involute spur gears with 16° pressure angle and pitch of module 6 mm is in mesh. The number of teeth on pinion is 16 and its rotational speed is 240 r.p.m. When the gear ratio is 1.75, find in order that the interference is just avoided ; **1.** the addenda on pinion and gear wheel ; **2.** the length of path of contact ; and **3.** the maximum velocity of sliding of teeth on either side of the pitch point.	3	3	5
4	Draw the profile of the cam operating a rocker reciprocating follower and with the following data. Minimum radius of the cam = 25 mm , lift = 30 mm, roller diameter = 15 mm. then the follower lowers during 150^0 of the cam rotation with UARm rotation followed by dwell period. Then the cam rotates at a uniform speed of 150 rpm (cw). The axis of the follower passes through the axis of the camshaft. Calculate velocity and acceleration	3	3	5
5	A pinion of 32 teeth and 4 mm module and drives a rack in which the pressure angle is 20^0. Addendum of both pinion and rack is same. Determine the maximum permissible value of addendum to avoid interference , also find the no of pairs of teeth is in contact.	3	3	5

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17ME42

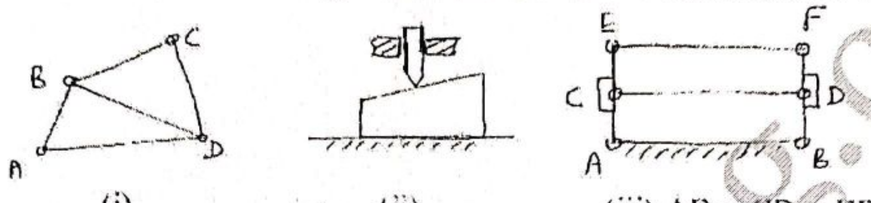
Fourth Semester B.E. Degree Examination, June/July 2019
Kinematics of Machinery

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Define 'degree of freedom' and find degree of freedom for the chains shown in Fig.Q1(a).



(i) (ii) (iii) AB = CD = EF & AE = BF

Fig.Q1(a) **(10 Marks)**

b. Define 'inversion of a kinematic chain'. A four bar mechanism has links of lengths 150mm, 250mm, 300mm and frame L_0 mm. Find the range of L_0 if the mechanism has to work as (i) Double crank mechanism (ii) Crank-rocker mechanism. **(10 Marks)**

OR

2 a. Sketch a neat, proportionate 'Peaucellier's mechanism'. State geometric relationships among links. Identify the point tracing the straight line and prove that the point traces straight line. **(10 Marks)**

b. Draw 'Crank and Slotted lever' type of quick return motion mechanism showing the positions of crank clearly for extreme positions of lever. If the crank and frame are 200 mm, 800mm, find the ratio of time of return to time of cutting if the crank rotates uniformly. Also find angle of oscillation of lever. **(10 Marks)**

Module-2

3 In a four bar mechanism ABCD, AD is fixed link of 120 mm long. The crank AB is 30mm and rotates at 100 rpm clockwise, while CD = 60 mm oscillates about D. BC and AD are of same length. Find the angular velocity of link CD when angle BAD = 60° by
(i) relative velocity method (ii) instantaneous centre method. **(20 Marks)**

OR

4 a. State and prove Kennedy's theorem. **(08 Marks)**

b. Explain the procedure to construct 'Klein's construction' to determine the velocity and acceleration of a slider crank mechanism in which crank is rotating uniformly. **(12 Marks)**

Module-3

5 a. For the slider crank mechanism shown in Fig.Q5(a), write (i) loop closure equation (ii) differentiate loop closure equation with respect to time to get velocity equation (iii) differentiate velocity equation with respect to time to get acceleration equation.

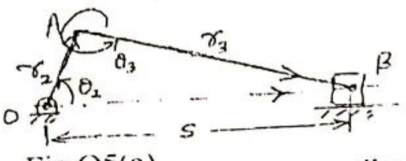


Fig.Q5(a) ***(08 Marks)***

b. In Fig.Q5(a), if r_2 = 100mm r_3 = 350mm, $\theta_2 = 60°$, find angular velocity and angular acceleration of connecting rod if crank rotates uniformly at 600 rpm in CCW direction. **(12 Marks)**

OR

6 a. For the 4-bar mechanism shown in Fig.Q6, obtain Frendenstein's equation. **(08 Marks)**

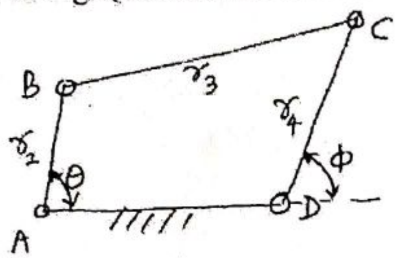


Fig.Q6

b. Find r_2, r_3 and r_4 to generate a function $y = x^3$, $1 \le x \le 3$ accurate at x = 1.1339, x = 2 and x = 2.866 if r_1 = 100mm, $\theta_s = 30°$, $\theta_f = 90°$, $\phi_s = 45°$ and $\phi_f = 135°$ with respect to Fig.Q6. **(12 Marks)**

Module-4

7 a. Define 'pitch circle', 'circular pitch', 'diametral pitch' and 'module'. **(08 Marks)**

b. Obtain an expression for the minimum number of teeth on pinion to avoid interference. **(12 Marks)**

OR

8 An epicyclic gear train consists of a sun-wheel S, a stationary internal gear E and three identical planet wheels P carried on a star shaped planet carrier C. The size of different tooth wheels are such that the planet carrier C rotates at $1/5^{th}$ of the speed of the sunwheel S. The no. of teeth on sun-wheel is 16. The driving torque on the sun-wheel is 100 N-m. Determine (i) no. of teeth on P and E (ii) Torque required to keep the internal gear stationary. **(20 Marks)**

Module-5

9 From the following data draw the profile of a cam in which the follower moves with SHM during ascent while it moves with uniform acceleration and deceleration during descent.

Cam rotates in anticlockwise ; Lift of follower : 4 cm

Least radius of cam : 5 cm : Angle of ascent : 48°

Angle of dwell between ascent and descent : 42° ;

Angle of descent = 60°

The diameter of roller = 3 cm

If cam rotates at 360 rpm, find maximum velocity and acceleration of the follower during descent. **(20 Marks)**

OR

10 a. Explain with sketch in brief 'radial cam' and 'cylindrical cam'. **(06 Marks)**

b. Obtain expressions for displacement, velocity and acceleration for a flat faced follower in contact with circular flank of a cam. **(14 Marks)**