INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	**KINEMATICS OF MACHINERY**
Course Code	**AME009**
Class	IV Semester
Branch	MECHANICAL ENGINEERING
Year	2018 – 2019
Course Faculty	Dr. K. Viswanath Allamraju Prof. V.V.S.H Prasad

COURSE OBJECTIVES (COs):

The course should enable the students to:

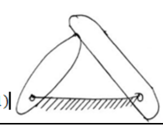
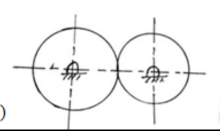
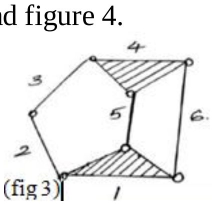
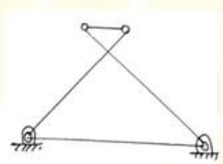
I	Understand the basic principles of kinematics and the related terminology of machines.
II	Identify mobility, enumerate links and joints in the mechanisms.
III	Explain the concept of analysis of different mechanisms.
IV	Understand the working of various straight line mechanisms, gears, gear trains, steering gear mechanisms, cams and a Hooke’s joint.
V	Determine the mechanisms for displacement, velocity and acceleration of links in a machine.

COURSE LEARNING OUTCOMES:

Students, who complete the course, will have demonstrated the ability to do the following:

S. No.	Description
CAME009.01	Classifications of the kinematic links, kinematic pairs and formation of the kinematic chain.
CAME009.02	Distinguish between mechanism and machine
CAME009.03	Design and develop inversions of quadratic cycle chain, slider crank mechanism, and double slider crank mechanism and cross slider mechanism.
CAME009.04	Demonstrate type synthesis, number synthesis and dimensional synthesis.
CAME009.05	Construct Graphical methods of velocity polygon and acceleration polygons for a given configuration diagram.
CAME009.06	Understand other methods of acceleration diagrams like Klien’s construction.
CAME009.07	Develop secondary acceleration component i.e Correli’s component involving quick return mechanisms
CAME009.08	Alternative approach for determining velocity by using I centres and centriods methods.
CAME009.09	Significance of exact and approximate straight line mechanisms.
CAME009.10	Application of straight line mechanism in steam engine indicators.
CAME009.11	Applications of Ackerman’s and Davi’s steering mechanisms in automobiles.
CAME009.12	Develop the condition for exact steering.
CAME009.13	Develop the polar velocity diagram for a single hook joint and double hook joint and develop condition for unity for higher and lower speeds.

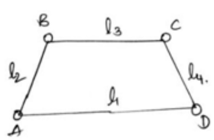
CAME009.14	Study different displacement profiles applicable in I.C engines cam shafts.
CAME009.15	Plot the displacement, velocity and acceleration profiles with respect to time.
CAME009.16	Understand the geometry of gears and deduce the expression for arc of contact.
CAME009.17	Derive the expression for minimum number of teeth to avoid interference in case of pinion and gear as well as rack and pinion.
CAME009.18	Application of different gear trains including epicyclic and deduce the train value using tabular and relative velocity method.
CAME009.19	Significance of differential gear box in an automobile while taking turn on the road.
CAME009.20	Enable the students to understand the importance of theory of machines for lifelong learning, Higher Education and competitive exams.

UNIT – I			
MECHANISMS			
PART - A (SHORT ANSWER QUESTIONS)			
S. No	**Question**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	Define link.	Remember	CAME009.01
2	Define mechanism.	Remember	CAME009.02
3	Explain the quick return motion mechanism of crank and slotted lever.	Remember	CAME009.02
4	Explain the whit-worth quick return motion mechanism.	Remember	CAME009.03
5	Define machine and structure.	Remember	CAME009.03
6	Define inversion of a mechanism.	Remember	CAME009.03
7	Explain Grubler’s criterion.	Remember	CAME009.03
8	Explain the degrees of freedom of a mechanism.	Understand	CAME009.03
9	List the types of kinematic pairs.	Understand	CAME009.03
10	Define the types of links with examples.	Remember	CAME009.01
11	What is Grashof’s linkage?	Remember	CAME009.03
12	Double crank mechanism in a parallelogram linkage. Justify your answer with neat diagram	Understand	CAME009.02
13	Give the classification of kinematic links	Understand	CAME009.03
14	Differentiate between Mechanism and machine	Understand	CAME009.03
15	Derive Grublers criterion for the constrained motion of a planar mechanism with lower pairs.	Understand	CAME009.02
16	Determine the degrees of freedom of linkage shown in figure 1 and figure 2. (fig 1)  (fig 2) 	Understand	CAME009.02
17	Determine the degrees of freedom of linkage shown in figure 3 and figure 4. (fig 3)  (fig 4) 	Understand	CAME009.03

18	Determine the degrees of freedom of linkage shown in figure 4.	Understand	CAME009.03
19	Justify your answer for 1 spring pair =2 binary pairs	Remember	CAME009.03
20	"Slider crank mechanism is an extension of four bar mechanism". Justify	Remember	CAME009.02

PART - B (LONG ANSWER QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Course Learning Outcomes
1	a) Define link and kinematic pair. b) Enumerate the inversions of double slider crank chain mechanism	Understand	CAME009.01
2	a) Define machine and mechanism. b) Enumerate the inversions of single slider crank chain mechanism	Understand	CAME009.02
3	a) Explain the quick return motion mechanism of crank and slotted lever. b) The length of the fixed link in a crank and slotted lever quick return mechanism is 300 mm and crank is 110 mm. Determine the inclination of the slotted lever with the vertical in the extreme position.	Understand	CAME009.02
4	a) Identify the difference between a machine and a structure. b) Classify kinematic pairs.	Remember	CAME009.02
5	a) Explain the Whitworth quick return motion mechanism. b) In a Whitworth quick return motion mechanism, the distance between the fixed centers is 50 mm and the length of the driving crank is 75 mm. The length of the slotted lever is 150 mm and the length of the connecting rod is 135 mm. Find the ratio of time of cutting and return strokes and also the effective stroke.	Remember	CAME009.03
6	a) Define machine and structure. b) Explain different types of constrained motions.	Remember	CAME009.03
7	a) Explain the function of Oldham's coupling. b) Prove that the elliptical trammel describes an ellipse.	Understand	CAME009.03
8	a) Define inversion of a mechanism? b) Explain the inversions of a quadric cycle chain?	Understand	CAME009.03
9	a) Explain Grubler's criterion. b) Identify the degrees of freedom for four bar mechanism, slider crank mechanism and five bar mechanism.	Understand	CAME009.04
10	a) What is meant by degrees of freedom of a mechanism? b) Explain the applications of Kutzback criterion to plane mechanisms.	Understand	CAME009.04
11	A crank and slotted lever mechanism used in a shaper has a centre distance of 300 mm between the centre of oscillation of the slotted lever and the centre of rotation of the crank. The radius of the crank is 120mm. Find the ratio of the time of cutting to the time of return stroke.	Remember	CAME009.03
12	The Whitworth quick return motion mechanism has the driving crank 150 mm long. The distance between fixed centres is 100 mm. The line of stroke of the ram passes through the centre of rotation of the slotted lever whose free end is connected to the ram by a connecting link. Find the ratio of time of cutting to time	Remember	CAME009.03

<table>
<tr><td></td><td>of return.</td><td></td><td></td></tr>
<tr><td>13</td><td>In a crank and slotted lever quick return mechanism, the distance between the fixed centers is 150 mm and the driving crank is 75 mm long. Determine the ratio of the time taken on the cutting and return Strokes</td><td>Understand</td><td>CAME009.03</td></tr>
<tr><td>14</td><td>In a crank and slotted lever quick return mechanism, the distance between the fixed centers is 150 mm and the driving crank is 75 mm long. Determine the ratio of the time taken on the cutting and return Strokes</td><td>Understand</td><td>CAME009.03</td></tr>
<tr><td>15</td><td>In a crank and slotted lever quick return motion mechanism, the distance between the fixed centre’s O and C is 200 mm. The driving crank CP is 75 mm long. The pin Q on the slotted lever, 360 mm from the fulcrum O, is connected by a link QR 100 mm long, to a pin R on the ram. The line of stroke of R is perpendicular to OC and intersects OC produced at a point 150 mm from C. Determine the ratio of times taken on the cutting and return strokes.</td><td>Remember</td><td>CAME009.03</td></tr>
<tr><td>16</td><td>In a crank and slotted lever quick return mechanism, the driving crank length is 30 mm and inclines at 30^0 to the vertical. The distance between the fixed centre’s is 200 mm and the length of the slotted lever is 500mm. Find the ratio of the times taken on the cutting and idle strokes. Determine the effective stroke also.</td><td>Remember</td><td>CAME009.03</td></tr>
<tr><td>17</td><td>A Whitworth quick return motion mechanism, has the following particulars: Length of stroke = 150mm ; Driving crank length = 40 mm; Time of cutting stroke= 2Time of return stroke. Find the lengths of connecting rod and slotted lever.</td><td>Remember</td><td>CAME009.03</td></tr>
<tr><td>18</td><td>A Four bar mechanism shown in fig foe each set of link proportions in the table below. Determine the mechanism described and draw the inversions of each mechanism.


<table>
<tr><th>Mechanism number</th><th>AD (cm) l_1</th><th>DC l_2</th><th>CB l_3</th><th>AB l_4</th></tr>
<tr><td>1</td><td>5</td><td>4</td><td>3.6</td><td>2.2</td></tr>
<tr><td>2</td><td>3</td><td>8.1</td><td>5.4</td><td>9</td></tr>
<tr><td>3</td><td>1</td><td>4.9</td><td>3</td><td>3.9</td></tr>
<tr><td>4</td><td>2.2</td><td>17</td><td>4.6</td><td>4</td></tr>
</table></td><td>Understand</td><td>CAME009.03</td></tr>
<tr><td>19</td><td>Explain the quick return motion mechanism of crank and slotted lever.</td><td>Understand</td><td>CAME009.03</td></tr>
<tr><td>20</td><td>Explain the whit-worth quick return motion mechanism.</td><td>Understand</td><td>CAME009.03</td></tr>
<tr><td colspan="4">PART - C (ANALYTICAL QUESTIONS)</td></tr>
<tr><td>1</td><td>The Whitworth quick return motion mechanism has the driving crank 150mm long. The distance between fixed centers is 100mm. The line of stroke of the ram passes through the center of rotation of the slotted lever whose free end is connected to the ram. Find the ratio of the time of cutting to the time of return.</td><td>Understand</td><td>CAME009.03</td></tr>
<tr><td>2</td><td>In the crank and slotted lever quick return mechanism, the distance between the fixed centers is 150 mm and the driving crank is 75mm long. Find the ratio of the time of cutting to the time of return.</td><td>Understand</td><td>CAME009.02</td></tr>
<tr><td>3</td><td>Sketch and explain any two inversions of a double slider crank</td><td>Remember</td><td>CAME009.03</td></tr>
</table>

	chain.		
4	What is the difference between Whitworth quick return motion mechanism and Crank and Slotted lever mechanism.	Remember	CAME009.01
5	Sketch and explain the various inversions of a four bar chain.	Remember	CAME009.02

UNIT-II

KINEMATICS, PLANE MOTION OF BODY, ANALYSIS OF MECHANISMS

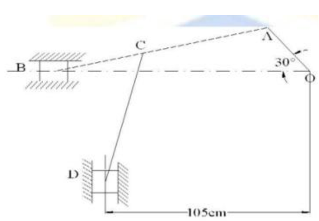
PART - A (SHORT ANSWER QUESTIONS)

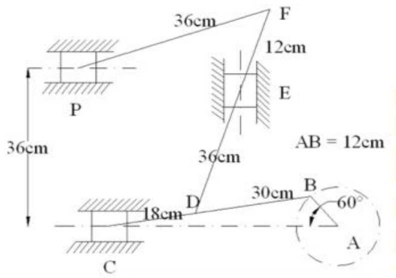
S. No	Question	Blooms Taxonomy Level	Course Learning Outcomes
1	Define Instantaneous centre.	Remember	CAME009.05
2	State and explain the Kennedy's theorem.	Remember	CAME009.08
3	Explain Klien's construction for determining acceleration of slider.	Remember	CAME009.06
4	Define axode.	Understand	CAME009.08
5	What is acceleration image?	Understand	CAME009.06
6	Define relative velocity.	Understand	CAME009.06
7	Define instantaneous axis.	Understand	CAME009.07
8	Define body centrode.	Understand	CAME009.08
9	Define space centrode.	Understand	CAME009.07
10	Define Coriolis component of acceleration.	Remember	CAME009.06
11	Define rubbing velocity.	Remember	CAME009.07
12	Define sliding velocity.	Remember	CAME009.07
13	Illustrate the space centrode and body centrode.	Remember	CAME009.08
14	List the various types of instantaneous centers.	Understand	CAME009.07
15	What is the formulation to calculate the no of instantaneous centers are in a mechanism?	Understand	CAME009.07
16	What are the expression for radial and tangential component of acceleration?	Understand	CAME009.07
17	How will you determine the magnitude of Coriolis component of acceleration	Understand	CAME009.07
18	How will you determine the direction of Coriolis component of acceleration	Remember	CAME009.07
19	State the properties of instantaneous centre method	Remember	CAME009.07
20	What is velocity Image?	Understand	CAME009.06

PART - B (LONG ANSWER QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Course Learning Outcomes
1	a) Mention different types of instantaneous centers. b) Locate the instantaneous centers for crank and slotted lever quick return mechanism?	Remember	CAME009.07
2	a)Define Instantaneous center. b) Locate all the Instantaneous centers of slider crank mechanism with crank length of 25mm rotating clockwise at a uniform speed of 100rpm. The crank makes 45^0 with IDC and the connecting rod is 400mm long. Determine the velocity of the slider and the angular velocity of connecting rod?	Remember	CAME009.07

3	a) State and explain the Kennedy's theorem. b) In a slider crank mechanism, the crank OA makes 400 rpm in the counter clockwise direction which is 60^0 from IDC. The lengths of the links are OA= 60 mm, OB= 220 mm and BA= 280 mm. Determine the velocity and acceleration of the slider B?	Understand	CAME009.08
4	a) Explain Klien's construction for determining velocity and acceleration of slider crank mechanism. b) Explain the method of determining the Coriolis component of acceleration in crank and slotted lever quick return mechanism?	Remember	CAME009.08
5	Determine the velocity and acceleration of the link QR and RS in a four bar mechanism in which PQRS is a four bar mechanism with fixed link PS. Crank PQ rotates uniformly and makes an angle of 60^o with PS in anti-clockwise direction.. The length of the links are PQ=62.5mm, QR= 175mm, RS= 112.5mm and PS= 200mm. Crank PQ rotates at 10 radians/ second?	Remember	CAME009.06
6	a) Define centrode and axode. b) Derive the analytical method of determination of velocity and acceleration for a slider crank mechanism?	Understand	CAME009.06
7	a) Explain how the acceleration of a point in a link is determined when the acceleration of some other point on the same link is given in magnitude and direction. b) Draw the acceleration diagram of a slider crank mechanism.	Remember	CAME009.06
8	a) What is acceleration image? b) Draw and explain the velocity diagram of Whitworth quick return mechanism by assuming suitable proportions.	Remember	CAME009.06
9	Derive an expression for the magnitude of Coriolis component of acceleration.	Understand	CAME009.07
10	a) What is the practical significance of evaluating velocity and acceleration of members of a mechanism? b) Assuming suitable proportions determine the velocity and acceleration of a slider in Toggle mechanism.	Understand	CAME009.06
11	The Crank of a slider crank mechanisms rotates clockwise at a Constant speed of 600 r.p.m. The crank is 125 mm and connecting rod is 500 mm long. Determine 1. Linear velocity and acceleration of the mid Point of the connecting rod, and 2. Angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead centre position.	Understand	CAME009.06
12	In a four link mechanism, the dimensions of the links are AB=200 mm, BC=400mm, CD=450 mm and AD=600mm. At the instant when DAB=90°, the link AB has angular velocity of 36 rad/s in the clockwise direction. Determine (i) The velocity of point C, (ii) The velocity of point E on the link BC When BE =200 mm (iii) the angular velocities of links BC and CD, iv) acceleration of link of link BC.	Remember	CAME009.06
13	The dimensions of the various links of a mechanism, are as follows: OA=300 mm; AB=1200; BC=450 mm and CO=450	Remember	CAME009.06

	mm. if the crank OA rotates at 20 r.p.m. in the anticlockwise direction and gives motion to the mechanism, find, for given configuration: (1) Velocity of A and B (2) Angular velocity of AB (3) Linear acceleration of B.		
14	a) Derive the expressions for Velocity and acceleration of piston in reciprocating steam engine mechanism with neat sketch b) Derive the expression for Coriolis component of acceleration with neat sketch.	Understand	CAME009.06
15	In a slider crank mechanism, the length of the crank and the connecting rod are 100 mm and 400 mm respectively. The crank position is 45° from IDC, the crank shaft speed is 600 r.p.m. clockwise. Using analytical method. Determine (1) Velocity and acceleration of the slider, and (2) Angular velocity and angular acceleration of the connecting rod.	Remember	CAME009.06
16	Locate all instantaneous centers of the slider crank mechanism; the length of crank OB and Connecting rod AB are 125 mm and 500 mm respectively. The crank speed is 600 rpm clockwise. When the crank has turned 45° from the IDC. Determine (i) velocity of. slider' A' (ii)Angular Velocity of connecting rod 'AB'.	Remember	CAME009.06
17	In the mechanism shown in figure , the crank OA rotates at 20rpm anticlockwise and gives motion of sliding blocks B and D. The dimensions of various links are OA = 300mm, AB = 1200mm, BC = 450mm and CD = 450 mm. For the given configuration determine i) velocities of sliding at B and D, ii) angular velocity of CD iii) Linear acceleration of D and iv) angular acceleration of CD.  	Understand	CAME009.06
18	The crank and connecting rod of a theoretical steam engine are 0.5 m and 2m long respectively. The crank makes 180 rpm in the clockwise direction. When it has turned 450 from the inner dead centre position, determine : a) Velocity of piston b) Angular velocity of connecting rod. C) Velocity of point E on the connecting rod 1.5m from the gudgeon pin. D) velocity of rubbing at the pins of the crank shaft, crank and crank cross head when the diameters of their pins are 50mm and 60mm and 30mm respectively.	Remember	CAME009.07
19	A four-bar mechanism has the following link length in mm. Input, A0A = 25, AB = 70, output B_0B = 45 and frame A_0B_0 = 60. Coupler point A is above and B is below the horizontal frame link A_0B_0, respectively. When the input link is in an angular position of 105^o counter clockwise from the frame	Understand	CAME009.07

	link, draw the four bar mehcnism and locate all the instantaneous centres. If the input link rotates with a constant angular velocity of 2.5 rad/sec clockwise, determine the linear velocity of B of the output link and the angular velocity of the output link.		
20	In a steam engine mechanism shown in figure a) the crank AB rotates at 200 rpm. The dimensions of various links are AB = 12cm, BC = 48cm, CD = 18cm and DE =36cm, EF = 12 cm and FP = 36cm. Find the velocities of C,D,E,F and P. 	Remember	CAME009.07
PART - C (ANALYTICAL QUESTIONS)			
S. No	**Question**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	Locate all instantaneous centers of the slider crank mechanism; the length of crank OB and Connecting rod AB are 125 mm and 500 mm respectively. The crank speed is 600 rpm clockwise. When the crank has turned 45° from the IDC. Determine (i) velocity of. slider' A' (ii)Angular Velocity of connecting rod 'AB	Remember	CAME009.0
2	Explain the procedure to determine the velocity and acceleration of a slider crank mechanism by Klein's construction.	Remember	CAME009.0
3	Sketch and explain whit worth quick return motion mechanism	Remember	CAME009.0
4	A four-bar mechanism has the following link length in mm. Input, A_0A = 25, AB = 60, output B_0B = 45 and frame A_0B_0 = 45. Coupler point A is above and B is below the horizontal frame link A_0B_0, respectively. When the input link is in an angular position of 105^0 counter clockwise from the frame link, draw the four bar mechanism and locate all the instantaneous centers. If the input link rotates with a constant angular velocity of 3 rad/sec clockwise, determine the linear velocity of B of the output link and the angular velocity of the output link.	Understand	CAME009.0
5	Derive the expression for Coriolis component of acceleration with neat sketch.	Understand	CAME009.0
UNIT – III			
STRAIGHT LINE MOTION MECHANISMS, STEERING GEARS, HOOKE'S JOINT			
PART - A (SHORT ANSWER QUESTIONS)			
1	What are straight line mechanisms?	Understand	CAME009.10
2	What is Pantograph.	Understand	CAME009.10
3	What is Ackerman steering gear mechanism	Remember	CAME009.11
4	What is a Hooke's joint?	Remember	CAME009.13
5	What is a Double Hooke's joint.	Remember	CAME009.13
6	What is Davi's steering gear mechanism?	Remember	CAME009.11

7	What are the applications of Hooke’s joint.	Understand	CAME009.10
8	List the exact straight line mechanisms.	Understand	CAME009.10
9	List the approximate straight line mechanisms.	Understand	CAME009.10
10	What is copied straight line mechanism	Understand	CAME009.10
11	What is the use of pantograph?	Understand	CAME009.10
12	Sketch the Harts mechanism.	Understand	CAME009.11
13	Sketch the Peaucellier mechanism.	Understand	CAME009.11
14	Sketch the Roberts mechanism.	Remember	CAME009.11
15	Sketch the Scott Russell mechanism.	Remember	CAME009.11
16	Sketch the grass hoper mechanism.	Remember	CAME009.11
17	Sketch the Tchebecheffs mechanism.	Understand	CAME009.11
18	Sketch the Watt mechanism.	Understand	CAME009.11
19	Give the ratios of links for Tchebecheffs mechanism.	Understand	CAME009.11
20	Give the ratios of links for Grasshoper mechanism.	Understand	CAME009.11
PART - B (LONG ANSWER QUESTIONS)			
S. No	**Question**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	a) What are straight line mechanisms? b) Describe any one mechanism having all turning pairs that generate an exact straight line?	Remember	CAME009.10
2	a) Explain the Peaucellier’s straight line mechanism. b) Explain the principle of generation of straight line.	Remember	CAME009.10
3	a) What is an approximate straight line mechanism? b) Explain a mechanism which consists of a sliding pair.	Remember	CAME009.10
4	a) What is an exact straight line mechanism? b) Explain an exact straight line mechanism?	Remember	CAME009.10
5	a) Describe the Watt’s parallel mechanism for straight line motion. b) Derive the condition for generating a straight line in Watt’s mechanism?	Understand	CAME009.11
6	a) What is a Pantograph? What is its use? b) Explain Scot Russel mechanism with a neat sketch, Show that it generates a straight line?	Understand	CAME009.10
7	a) Differentiate between Davi’s and Ackerman steering gears. b) In a Davi’s steering gear, the distance between the pivots of the front axle is 1 meter and the wheel base is 2.5 meters. Find the inclination of the track arm to the longitudinal axis of the car when it is moving along a straight path?	Understand	CAME009.10
8	a) What is the condition for correct steering? b) Explain the Ackerman’s steering gear mechanism.	Understand	CAME009.11
9	a) What is a Hooke’s joint? What are its applications? b) A Hooke’s joint connects two shafts whose axes intersect at 1500.The driving shaft rotates uniformly at 120 rpm. The driven shaft operates against a steady torque of 150NM. And carries a flywheel whose mass is 45 kg and radius of gyration 150 mm. Find the maximum torque which will be exerted by the driving shaft.	Understand	CAME009.11
10	a) What is a Double Hooke’s joint? b) Derive an expression for the ratio of shaft velocities in a Hooke’s joint.	Understand	CAME009.13

11	Explain Scott Russel mechanism with a neat sketch, Show that it generates a straight line?	Understand	CAME009.13
12	Differentiate between Davi's and Ackerman steering gears	Understand	CAME009.11
13	In a Davi's steering gear, the distance between the pivots of the front axle is 1 meter and the wheel base is 2.5 meters. Find the inclination of the track arm to the longitudinal axis of the car when it is moving along a straight path?	Remember	CAME009.12
14	What is the condition for correct steering?	Remember	CAME009.12
15	Explain the Ackerman's steering gear mechanism.	Remember	CAME009.12
16	What is a Hooke's joint? What are its applications?		CAME009.12
17	A Hooke's joint connects two shafts whose axes intersect at 1500.The driving shaft rotates uniformly at 120 rpm. The driven shaft operates against a steady torque of 150NM. And carries a flywheel whose mass is 45 kg and radius of gyration 150 mm. Find the maximum torque which will be exerted by the driving shaft.	Understand	CAME009.13
18	What is a Double Hooke's joint?	Understand	CAME009.13
19	Derive an expression for the ratio of shaft velocities in a Hooke's joint.	Understand	CAME009.13
20	Explain the Davis's steering gear mechanism.	Understand	CAME009.12

PART - C (ANALYTICAL QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Course Learning Outcome
1	The track arm of a Davis steering gear is at a distance of 185 mm from the front main axle whereas the difference between their lengths is 90 mm. If the distance between steering pivots of the main axle is 1.2 m, determine the length of the chassis between the front and the rear wheels. Also find the inclination of the track arms to the longitudinal axis of the vehicle	Remember	CAME009.1
2	The distance between the steering pivots of a Davi's steering gear is 1.3 m. The wheel base is 2.75 m. what will be the inclination of the track arms to the longitudinal axis of the vehicle moving in a straight path.	Understand	CAME009.1
3	Give a neat sketch of the straight line motion 'Hart mechanism.' Prove that it produces an exact straight line motion.	Remember	CAME009.1
4	The driving shaft of a double Hook's joint rotates at 400 rpm. The angle of driving and driven shaft with intermediate shaft is 20^0. Determine the maximum and minimum velocities of the driven shaft.	Remember	CAME009.1
5	A hooks joint connects two shafts whose axes intercect at 25^0. What will be the angle turned by the driven shaft when the velocity ratio is maximum, minimum and unity.	Understand	CAME009.1

UNIT – IV

CAMS, ANALYSIS OF MOTION OF FOLLOWERS

PART - A (SHORT ANSWER QUESTIONS)

S.No	Question	Blooms Taxonomy Level	Course Learning Outcomes
1	Define cam.	Remember	CAME009.14
2	Define angle of action.	Remember	CAME009.14
3	Explain with the help of displacement diagrams the UARM.	Remember	CAME009.14
4	What are the uses of cams and followers?	Remember	CAME009.14
5	What is a tangent cam	Remember	CAME009.14

6	Define follower.	Remember	CAME009.14
7	Classify the cams.	Understand	CAME009.14
8	Classify the follower types.	Understand	CAME009.14
9	Define angle of dwell in cams.	Understand	CAME009.14
10	Define pressure angle in cams.	Understand	CAME009.15
11	What is meant by angle of ascend?	Understand	CAME009.15
12	What is meant by angle of descend?	Understand	CAME009.15
13	What is the application of cam?	Remember	CAME009.15
14	What is meant by angle of action?	Remember	CAME009.14
15	What is dwell?	Remember	CAME009.15
16	What are the classifications of followers according to the path of motion?	Understand	CAME009.15
17	What is the motion of the follower?	Understand	CAME009.15
18	What are the necessary elements of a cam mechanism?	Understand	CAME009.14
19	Write the formula for maximum velocity.	Understand	CAME009.15
20	What are the classifications of follower according to the motion of the follower?	Understand	CAME009.15

PART - B (LONG ANSWER QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Course Learning Outcomes
1	a) Define a cam and mention the types? b) What are the various motions possible with cam and follower?	Remember	CAME009.14
2	a) Define a follower and mention the types? b) Draw and explain the displacement and velocity diagrams for uniform	Remember	CAME009.14
3	a) Define the following terms as applied to cams with neat sketch: i) Base circle ii) pitch circle iii) pressure angle. b) Draw the profile of a cam with oscillating roller follower for the following motion: Follower to move outwards through an angular displacement of 20^0 during 120^0 of cam rotation, follower to dwell for 50^0, follower to return to its initial position during 90^0 of cam rotation with UARM, follower to dwell for the remaining period.	Remember	CAME009.14
4	a) Write short notes on cams and followers. b) Draw a cam to raise a valve through a distance of 50 mm in 1/3 of revolution with SHM, keep it fully raised through 1/12 of revolution and lower it with harmonic motion in 1/6 of revolution. The valve remains closed during the rest of the revolution. The diameter of the roller is 20mm and the minimum radius of the cam is 25 mm. The axis of the valve rod passes through the axis of the cam shaft	Understand	CAME009.15
5	a) Draw and explain the displacement and velocity diagrams for Simple Harmonic motion. b) Lay out the profile of a cam so that the follower is to move outwards through 30 mm during 160^0 of cam rotation with Uniform velocity and dwell for 30^0 of cam rotation followed by returning to initial position with Uniform acceleration and retardation during 110^0 of cam rotation and dwell for the remaining period. The base circle diameter of cam is 28mm and the follower is a knife edge follower. The axis of the	Remember	CAME009.15

	follower is offset by 6 mm.		
6	a) Define angle of action, angle of dwell and pressure angle in cams. b) Lay out the profile of a cam so that the follower is to move outwards through 30 mm during 180^0 of cam rotation with SHM and dwell for 20^0 of cam rotation followed by returning to initial position with Uniform velocity during 160^0 of cam rotation. The base circle diameter of cam is 28 mm and the roller diameter is 8 mm. The axis of the follower is offset by 6 mm.	Remember	CAME009.15
7	a) Explain with the help of displacement, velocity and acceleration diagrams the UARM. b) A cam operating a knife edge follower has the following data: Follower moves outward through 40 mm during 60^0 of cam rotation with uniform velocity, follower dwells for the next 45^0, follower returns to its original position during next 90^0 with Uniform velocity and dwells for the remaining period. Draw the cam profile.	Understand	CAME009.15
8	a) What are the uses of cams and followers? b) A radial translating flat faced follower has a lift of 30 mm. The rise takes place with SHM during 180^0 of cam rotation. The return also takes place with SHM during the next 180^0 of cam rotation. Assume anti clockwise rotation of the cam. Draw the cam profile and determine the maximum velocity and acceleration values when the follower rises and the cam rotates at 50 rpm.	Remember	CAME009.15
9	a) Why a roller follower is preferred to a knife edge follower? b) Derive expressions for displacement, velocity and acceleration for a tangent cam operating a radial translating roller follower when the contact is on circular nose.	Remember	CAME009.15
10	a) What is a tangent cam? b) Derive an expression for the tangent cam when the follower is contacting the convex flanks.	Understand	CAME009.15
11	A cam is to give the following motion to a knife edged follower: (a) Outstroke during 60° of cam rotation (b) Dwell for the next 45° of cam rotation (c) Return stroke during next 90° of cam rotation and (d) Dwell for the remaining of cam rotation The stroke of the follower is 40 mm and the minimum radius of the cam is 50 mm. The follower moves with uniform velocity during both the outstroke and return strokes. Draw the profile of the cam when (a) the axis of the follower passes through the axis of the cam shaft, and (b) the axis of the follower is offset by 20 mm from the axis of the cam shaft.	Understand	CAME009.15
12	Draw the profile of a cam operating a Knife-edged follower from the following data: (a) Follower to move outward through 40 mm during 60° of a cam rotation; (b) Follower to dwell for the next 45° (c) Follower to return its original position during next 90° (d)Follower to dwell for the rest of cam 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 50mm. If the cam rotates at 300 r.p.m., determine the maximum velocity and acceleration of the follower during the outward stroke and return stroke.	Remember	CAME009.15

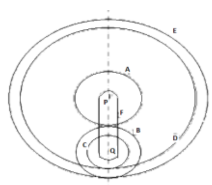
13	A cam, with a minimum radius of 50 mm, rotating clockwise at a uniform speed, is required to given a knife-edged follower the motion as described below: (a) To move outwards through 40 mm during 100° rotation of the cam; (b) to dwell for next 80° (c) To return to its starting position during next 90 ° and (d) To dwell for the rest period of revolution. Draw the profile of the cam (i) When the line of stroke of the follower passes through the centre of the cam shaft and (ii) When the line of stroke of the follower is to take place with Uniform acceleration and uniform retardation. Determine the maximum velocity and acceleration of the follower when the cam shaft rotates at 900 r.p.m.	Remember	CAME009.15
14	Draw the profile of a cam operating a roller reciprocating follower and with the following data: Minimum radius of cam =25 mm; lift=30mm; Roller diameter= 15mm. The cam lifts the follower for 120° with SHM, followed by a dwell period of 30°. Then the follower lowers down during 150° of cam rotation with uniform acceleration and retardation followed by a dwell period. If the cam rotates at a uniform speed of 150 RPM. Calculate the maximum velocity and acceleration of follower during the descent period.	Remember	CAME009.15
15	It is required to set out the profile of a cam to give the following motion to the reciprocating follower with a flat mushroom contact surface: (i) Follower to have a stroke of 20 mm during 120° of cam rotation, (ii) Follower to dwell for 30° of cam rotation, (iii) Follower to return to its initial position during 120° of cam rotation, (iv) Follower to dwell for remaining 90° of cam rotation. The minimum radius of the cam is 25 mm. The out stroke of the follower is performed with SHM and return stroke with equal uniform acceleration and retardation.	Understand	CAME009.15
16	A tangent cam to drive a roller follower through a total lift of 12.5 mm for a cam rotation of 75°.The cam speed is 600 rpm. The distance between cam centre and follower centre at full lift is 45 mm and the roller is 20 mm in diameter. Find the cam proportions and plot displacement, velocity and acceleration for one full cycle.	Understand	CAME009.15
17	Construct a tangent cam and mention the important terminologies on it. Also derive the expression for displacement, velocity, acceleration of a reciprocating roller follower when the roller has contact with the nose.	Remember	CAME009.15
18	Layout the profile of a cam operating a roller reciprocating follower for the following data. Lift of follower = 30mm; Angle during the follower rise period $=120^0$; angle during the follower after rise = 30^0; angle during the follower return period = 150^0. Angle during which follower dwell after return = 60^0; minimum radius of cam = 25mm; Roller diameter 10mm. The motion of follower is uniform acceleration and deceleration during the rise and return period.	Remember	CAME009.15
19	Design a cam to raise a valve with simple harmonic motion through 15mm is 1/3rd of a revolution, keep it fully raised through 1/12th of a revolution and to lower it with SHM in 1/6th of a revolution. The valve remains closed during the rest of the revolution. The diameter of the roller is 20mm and the minimum radius of the cam is 25mm. The axis of the valve rod passes through the axis of the cam shaft. If the cam shaft	Understand	CAME009.15

	rotates at uniform speed of 100 rpm; find the maximum velocity and acceleration of the valve during raising and lowering. Also draw the profile of the cam.		
20	a) Classify with neat sketches the cam follower according to their shape, location and motion. State also their advantages, if any, with respect to other followers b) Sketch neatly the displacement, velocity and acceleration curves of a SHM motion of Follower. Why is it superior over other motion curves?	Understand	CAME009.15
PART - C (ANALYTICAL QUESTIONS)			
S. No	**Question**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	Draw the profile of a cam operating a Knife-edged follower from the following data: (a) Follower to move outward through 40 mm during 60° of a cam rotation; (b) Follower to dwell for the next 45° (c) Follower to return its original position during next 90° (d) Follower to dwell for the rest of cam 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 50mm. If the cam rotates at 300 r.p.m., determine the maximum velocity and acceleration of the follower during the outward stroke and return stroke.	Remember	CAME009.17
2	A cam is to give the following motion to a knife edged follower: (a) Outstroke during 60° of cam rotation (b) Dwell for the next 60° of cam rotation (c) Return stroke during next 60° of cam rotation and (d) Dwell for the remaining of cam rotation The stroke of the follower is 80 mm and the minimum radius of the cam is 50 mm. The follower moves with uniform velocity during both the outstroke and return strokes. Draw the profile of the cam when (a) the axis of the follower passes through the axis of the cam shaft, and (b) the axis of the follower is offset by 10 mm from the axis of the cam shaft.	Remember	CAME009.16
3	Draw the profile of a cam operating a Knife-edged follower from the following data: (a) Follower to move outward through 40 mm during 60° of a cam rotation; (b) Follower to dwell for the next 30° (c) Follower to return its original position during next 90° (d)Follower to dwell for the rest of cam 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 50mm. If the cam rotates at 500 r.p.m., determine the maximum velocity and acceleration of the follower during the outward stroke and return stroke.	Understand	CAME009.17
4	A cam, with a minimum radius of 35 mm, rotating clockwise at a uniform speed, is required to given a knife-edged follower the motion as described below: (a) To move outwards through 40 mm during 90° rotation of the cam; (b) to dwell for next 90°	Understand	CAME009.17

	(c) To return to its starting position during next 90 ° and (d) To dwell for the rest period of revolution. Draw the profile of the cam (i) When the line of stroke of the follower passes through the centre of the cam shaft and (ii) When the line of stroke of the follower is to take place with Uniform acceleration and uniform retardation. Determine the maximum velocity and acceleration of the follower when the cam shaft rotates at 600 r.p.m.		
5	Draw the profile of a cam operating a roller reciprocating follower and with the following data: Minimum radius of cam =25 mm; lift=60mm; Roller diameter = 15mm. The cam lifts the follower for 180° with SHM, followed by a dwell period of 30°. Then the follower lowers down during 120° of cam rotation with uniform acceleration and retardation followed by a dwell period. If the cam rotates at a uniform speed of 150 RPM. Calculate the maximum velocity and acceleration of follower during the descent period.	Remember	CAME009.18
	UNIT – V		
	HIGHER PAIRS, GEAR TRAINS		
	PART - A (SHORT ANSWER QUESTIONS)		
S. No	**Question**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	Explain spur gears?	Remember	CAME009.16
2	Describe cycloidal gears?	Remember	CAME009.16
3	Explain the method of eliminating interference in gears	Remember	CAME009.17
4	What is a gear train and list its types?	Remember	CAME009.18
5	What is a Differential?	Remember	CAME009.16
6	Explain helical gears.	Remember	CAME009.16
7	Classify bevel gears?	Understand	CAME009.16
8	What is interference?	Understand	CAME009.16
9	Mention the involute profiles of gears?	Understand	CAME009.17
10	Define pressure angle of gears.	Understand	CAME009.17
11	Define addendum and dedendum.	Understand	CAME009.17
12	Define circular pitch.	Remember	CAME009.17
13	Define path of contact.	Remember	CAME009.16
14	Define Length of path of contact.	Remember	CAME009.17
15	State the law of gearing.	Understand	CAME009.17
16	Define angle of approach.	Understand	CAME009.17
17	Define contact ratio.	Understand	CAME009.17
18	Define helix angle.	Understand	CAME009.17
19	Define gear ratio.	Understand	CAME009.17
20	Define epicyclic gear train.	Understand	CAME009.18
	PART - B (LONG ANSWER QUESTIONS)		
S. No	**Question**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	a) Explain spur, helical and bevel gears? b) Derive an expression for the length of path of contact.	Understand	CAME009.17
2	a) Explain the terms module, pressure angle and addendum in gears.	Understand	CAME009.17

	b) Two mating gears have 29 and 40 involute teeth of module 10 mm and 20^0 pressure angle. If the addendum on ach wheel is such that path of contact is maximum and interference is just avoided ,find the addendum for each gear wheel, path of contact, arc of contact and contact ratio.		
3	a) Explain the terms module, pressure angle and addendum in gears. b) Two mating gears have 29 and 40 involute teeth of module 10 mm and 20^0 pressure angle. If the addendum on ach wheel is such that path of contact is maximum and interference is just avoided ,find the addendum for each gear wheel, path of contact, arc of contact and contact ratio.	Remember	CAME009.17
4	a) Explain the method of eliminating interference in gears. b) A pair of gears having 40 and 20 teeth respectively are rotating in mesh The speed of the smaller is 2000 rpm. Determine the velocity of sliding at the point of engagement, at the pitch point and at the point of disengagement. Assume that the gear teeth are200 involute, addendum is 5 mm and module is 5 mm.	Remember	CAME009.17
5	a) Derive an expression for the length of arc of contact. b) The pitch circle diameter of the smaller of the two gears which mesh externally and have involute teeth is 100 mm. The number of teeth is 16 and 32. The pressure angle is 200. The addendum is 0.32 of the circular pitch. Find the length of path of contact of the pair of teeth.	Understand	CAME009.17
6	a) Derive an expression for the minimum number of teeth on pinion to avoid interference. b) The pressure angle of two gears in mesh is 200 and have a module of 10 mm. The number of teeth on pinion are 24 and on gear 60. The addendum of pinion and gear is same and equal to one module. Determine the number of pairs of teeth in contact, the angle of action of pinion and gear, the ratio of sliding to rolling velocity at the beginning of contact, at pitch point and at the end of contact.	Remember	CAME009.17
7	a) What is a gear train and what are its types? b) The speed ratio of a reverted gear train is 12. The module pitch of gears A and B which are in mesh is 3.125 mm and of gears C and D which are in mesh is 2.5 mm. Calculate the suitable number of teeth for the gears. No gear is to have less than 20 teeth. B-C is a compound gear.	Remember	CAME009.18
8	a) Explain with a neat sketch the sun and planet wheel. b) In an epicyclic gear train, an arm carries two gears 1 and 2 having 40 and 50 teeth respectively. The arm rotates at 160 rpm counter clockwise about the centre of gear1, which is fixed. Determine the speed of gear2.	Understand	CAME009.17
9	a) What is a Differential? b) An internal wheel B with 80 teeth is keyed to a shaft F. A fixed internal wheel C with 82 teeth is concentric with B. A compound wheel D-E gears with two internal wheels. D has 28 teeth and gears with C while E gears with B. The compound wheels revolve freely on a pin which projects from a disc keyed to shaft A coaxial with F. If the wheels have the same pitch and the shaft rotates at 800 rpm what is the speed of the shaft F? Sketch the arrangement.	Remember	CAME009.18
10	In an epicyclic gear train, internal gear A is keyed to the driving shaft and has 30 teeth. Compound wheel CD of 20 and 22 teeth respectively are free to rotate on a pin fixed to the arm P which is rigidly connected to the driven shaft. Internal gear B which has 32 teeth is fixed. If the driving shaft runs at 60 rpm clock wise, determine the speed of the driven shaft.	Remember	CAME009.18

11	In a reverted epicyclic train, the arm F carries two wheels A and D and a compound wheel B-C. Wheel A meshes with wheel B and Wheel D meshes with wheel C. The number of teeth on wheel A, D and C are 80, 48, and 72. Find the speed and direction of wheel D , when wheel A is fixed and arm F makes 200 rpm clockwise.	Remember	CAME009.17
12	Two mating spur gear with module pitch of 6.5 mm have 19 ad 47 teeth of 20° pressure angle and 6.5 mm addendum. Determine the number of pair of teeth and angle turned through by the larger wheel for one pair of teeth in contact. Determine also the sliding velocity at the instant (i) engagement commences (ii) engagement terminates. When the pitch line velocity is 1.2 m/s.	Understand	CAME009.17
13	The number of teeth on each of the two spur gears in mesh is 40. The teeth have 20° involute profile and the module is 6mm. If the arc of contact is 1.75 times the circular pitch. Find the addendum.	Remember	CAME009.17
14	Two 20° involute spur gears have a module of 10 mm. The addendum is one module. The larger gear has 50 teeth and pinion 13 teeth. Does the interference occur? If it occurs, to what value should the pressure angle be changed to eliminate interference?	Remember	CAME009.17
15	Two mating involute spur gears 20° pressure angle have a gear ratio of 2. the number of teeth on the pinion is 20 and its speed is 250 rpm. The module pitch of the teeth is 12 mm. if the addendum on each wheel wheel recess on each side are half the maximum possible length each, find (1) the addendum for pinion and gear wheel (2) the length of arc of contact (3 the maximum velocity of sliding during approach and recess. Assume pinion to be driver.	Remember	CAME009.17
16	A pair of spur gear with involute teeth is to give a gear ratio of 4:1. The arc of approach is not be less than the circular pitch and the smaller wheel is the driver. The angle of pressure is 14.5 What is the least number of teeth can be used on each wheel? What is the addendum of the wheel in terms of circular pitch	Understand	CAME009.17
17	A pair 20° full depth involute spur gear having 30 and 50 teeth respectively module 4 mm arc in mesh, the smaller gear rotates at 1000 rpm. Determine (a) Sliding velocities at engagement and disengagement of a pair of teeth and (b) Contact ratio	Understand	CAME009.17
18	In an epicyclic gear train the internal wheels A and B and compound wheels C and D rotate independently about axis O. The wheels E and F rotate on pins fixed to the arm G. E gears with A and C . Wheel F gear with B and D. All the wheels have the same module and the number of teeth are: TC =28 TD=26; TE = TF=18. (1) Sketch the arrangement, (2) Find the number of teeth on A and B, (3)If the arm G makes 100 rpm clockwise and A is fixed, find the speed of B , and (4) If the arm G makes 100 rpm clockwise and wheel A makes 10 rpm counter clockwise; Find the speed of wheel B	Understand	CAME009.17
19	Two gear wheels mesh externally and are to give a velocity ratio of 3 to 1. The teeth are of involute form; module=6mm, addendum=one module, pressure angle= 20°. The pinion rotates at 90 rpm. Determine (1) the number of teeth on the pinion to avoid interference on it and the corresponding number of teeth on the wheel, (2) The length of path and arc of contact, (3) the number of pairs of teeth in contact.	Understand	CAME009.17
20	The arm of an epicyclic gear train rotates at 100 rpm in the anticlock wise direction. The arm carries two wheels A and B having 36 and 45 teeth respectively. The wheel A is fixed and the arm rotates about the centre of wheel A. Find the speed of wheel B. What will be the speed of B, if the wheel A instead of being fixed, makes 200 rpm (clockwise).	Understand	CAME009.17

PART - C (ANALYTICAL QUESTIONS)			
S. No	**Question**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	Draw the profile of a cam operating a roller reciprocating follower and with the following data: Minimum radius of cam =25 mm; lift=30mm; Roller diameter= 15mm. The cam lifts the follower for 120° with SHM, followed by a dwell period of 30°. Then the follower lowers down during 150° of cam rotation with uniform acceleration and retardation followed by a dwell period. If the cam rotates at a uniform speed of 150 RPM. Calculate the maximum velocity and acceleration of follower duringthe descent period.	Understand	CAME009.17
2	In a reverted epicyclic train, the arm F carries two wheels A and D and a compound wheel B-C. Wheel A meshes with wheel B and Wheel D meshes with wheel C. The number of teeth on wheel A, D and C is 80, 48, and 72. Find the speed and direction of wheel D , when wheel A is fixed and arm F makes 200 rpm clockwise	Remember	CAME009.18
3	Two Parallel shaft are connected by spur gearing. The distance between the shaft is 600mm. If one shaft runs at 120 rpm and the other at 360 rpm. Find the the number of teeth on each wheel, if module is 8 mm. Also determine the exact center distance between the shafts.	Remember	CAME009.17
4	A compound epicyclic gear is shown in figure. The gears A, D and E are free to rotate on axis P. The compound gears B and C rotate together on the axis Q at the end of arm F. All the gears have equal pitch. The number of external teeth on gears, A B and C are 18, 45 and 21 respectively. The gears D and E are annulus gears. The gear A rotates at 100 rpm in anticlockwise direction and the gear D rotates at 450 rpm clockwise. Find the speed and direction of the arm and the gear E.  	Remember	CAME009.17
5	A compound train consists of six gears. The number of teeth on the gears are as follows : Gear : A B C D E F No. of teeth: 60 40 50 25 30 24 The gears *B* and *C* are on one shaft while the gears *D* and*E* are on another shaft. The gear *A* drives gear *B*, gear *C* drives gear *D* and gear *E* drives gear *F*. If the gear *A* transmits 1.5 kW at 100 r.p.m. and the gear train has an efficiency of 80 pecent, find the torque on gear *F*.	Understand	CAME009.18

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