**Round 1- Dynamics of Machine Lab**

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### Department: Mechanical Engineering

### Discipline: Mechanical Engineering

### Name of the Lab: Dynamics of Machine Lab

### Name of experiment: Dynamics of Four Bar Mechanism

### Experiment Number: 1

### FOCUS AREA: Experimental Analysis Methods

**About the Experiment**:

A four bar link mechanism or linkage is the most fundamental of the plane kinematics linkages. It is a much-preferred mechanical device for the mechanization and control of motion due to its simplicity and versatility. It consists of four rigid links which are connected in the form of quadrilateral by four pin joints. The link adjacent to fixed link is called input link, the link opposite to the fixed link is the coupler and the link connecting coupler and fixed link is output link. According to type of motion, if the link complete a full revolution then it is called as crank, link that oscillates is called rocker.

Through the process of the simulation, one would understand how to calculate the forces on each link for a constant angular velocity as input. The dynamic analysis of the four bar mechanism is covered after understanding the kinematic analysis since the acceleration of the links are required to calculate the forces on the link.

**1. Learning Objectives and Cognitive Level:**

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| **Sr. No** | **Learning Objectives** | **Cognitive level** | **Action Verbs** |
| 1. Students will be able to: | State the concepts of dynamic analysis of four bar mechanisms | Recall | State |
| 2. Students will be able to: | Understand the significance of parameter and select the variables accordingly | Understand | Select |
| 3. Students will be able to: | Calculate the velocity, acceleration and force acting on each link. | Apply | Calculate |
| 4. Students will be able to: | Examine the calculated values with the simulation results | Analyse | Examine |
| 5. Students will be able to: | Evaluate how change in length, angle and driving force results in change of acceleration, velocity and work done by the mechanism | Evaluate | Evaluate |

**2. Instructional Strategy:**

### 2.1 Method: Expository

### 2.2 Assessment Method: Formative Assessment

### 2.3 Description:

### The animation of four bar mechanism is shown with velocity and acceleration diagram. The rotational speed and length of each link can be varied to change the motion of the mechanism. The animation of acceleration of CG and offset analysis is given. The acceleration values have been represented as a vector situated on the centre of the links which varies dynamically with respect to the variations in the input speed and angle. Offset analysis simplifies the forces acting on the body of the links by representing the torque acting on the body by displacing the inertial forces at a certain distance from the centre parallel to the inertial force. These offset distances are represented through the table. The mass of each link can be varied for understanding effect of forces on each link.

### 3. Task & Assessment Questions:

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| **Sr. No.** | **Instructions given by the Teacher** | **Tasks to be done by the Students** | **Assessment question aligned with the task** |
| 1. | Explain the dynamic forces acting on four bar mechanism | Understand the significance of the experiment and recall its applications. | Q.1, Q2, Q.4, Q5, Q6, Q7 |
| 2 | Explain the step by step procedure to be carried out in the experiment. | Understand the procedure to be followed to conduct the experiment. | Q.11, Q3, Q8 |
| 3 | Derive all the governing equation and to carryout required calculations | Apply the derived equations and calculate the values. | Q9, Q10, Q12 |
| 4 | Compare analytical value with simulation results | Note down the acceleration at the centre of the link, torque, forces acting on each link and compare it with analytical value | Q14 |
| 5 | Observe the changes in mechanism due to variation in parameter | Evaluate changes in acceleration, velocity and forces due to change in mass, torque and length of link. | Q15 |

### Additional Assessment Questions:

### Which of the following statement is correct as regard to the difference between a machine and a structure?

### A machine transforms the available energy into some useful work, whereas in a structure no energy is transformed into useful work

### The parts of a machine move relative to one another, whereas the members of a structure do not move relative to one another.

### The links of a machine may transmit both power and motion, whereas the members of a structure transmit forces only.

### All the above statement

### Answer: d

### Explanation: None

### A kinematic chain is known as a mechanism when

### Three of the links is fixed

### Two of the links is fixed

### One of the links is fixed

### None of the above

### Answer: c

### .

### The Grubler’s criterion for determining the degrees of freedom (n) of a mechanism having plane motion is

### N= 4(l-1)-3j

### N= 3(l-1)-2j

### N= 2(l-1)-2j

### N= (l-1)- j

### Answer: b

### What is the use of beam engine?

### To convert oscillatory motion into rotary motion

### To convert rotary motion into oscillatory motion

### To convert rotary motion into reciprocating motion

### To convert reciprocating motion into rotary motion

### Answer: c

### How many revolute joints are there in a four bar mechanism

### 1

### 4

### 6

### 8

### Answer: b

### **Which of the following is an inversion of four bar kinematic chain?**

### **Reciprocating engine**

### **Rotary engine**

### **Oscillating Engine**

### **Beam engine**

### **Answer: a**

### “Inversions of Four Bar Chain”.

### Match list 1 with list 2

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| --- | --- |
| List 1 | |
| A | Quick return Mechanism |
| B | Apron mechanism |
| C | Indexing mechanism |
| D | Regulating wheel |

|  |  |
| --- | --- |
| List 2 | |
| 1 | Lathe |
| 2 | Shaper |
| 3 | Milling machine |
| 4 | Centreless grinding |

### A-3, B-2, C-1, D-4

### A-2, B-1, C-3, D-4

### A-4, B-2, C-3, D-1

### A-2, B-3, C-4, D-1

### Answer: b

1. What is the Grashof linkage criterion?
2. s+l>p+q
3. s+l<p+q
4. s+p>l+q
5. s+p<l+q

Answer: B

1. How many equations in total are formed in the process of finding out the forces on each link?
2. 3
3. 6
4. 9
5. 12

Answer: C

1. How many forces are acting on each link due to other links?
2. 2
3. 3
4. 4
5. 5

Answer: A

1. What is the order of analysis of the four bar linkage?
2. Position analysis, Velocity analysis, Dynamic Analysis, Acceleration analysis
3. Dynamic Analysis, Acceleration analysis, Position analysis, Velocity analysis
4. Position analysis, Velocity analysis, Acceleration analysis, Dynamic Analysis
5. Dynamic Analysis, Position analysis, Velocity analysis, Acceleration analysis,

Answer: C

1. How many degrees of freedom does a four bar mechanism have?
2. 0
3. 1
4. 2
5. 3

Answer: B

1. What is the shortest link for the following category of four bar mechanism?
2. Double crank (s + l < p + q)
3. Double rocker (s + l < p + q)
4. Frame and coupler
5. Frame and side
6. Coupler and side
7. Coupler and frame

Answer: a

1. Consider a four bar mechanism with fixed link DC = 60 mm, input link DA = 30 mm, Coupler = 36 mm, output link = 66 mm. The driving link DA is rotating at 0.6 rad/sec. Velocity of A will be
2. 20 mm/s
3. 18 mm/s
4. 22 mm/s
5. 15 mm/s

Answer: 18 mm/s

1. What is the range of values of F14y from the simulator when T4=0.6, with four bar mechanism with fixed link DC = 60 mm, input link DA = 30 mm, Coupler = 36 mm, output link = 66 mm?
2. 5 to 22 N
3. 1 to 4 N
4. 10 to 12 N
5. 50 to 80 N

Answer: 5 to 22 N

### 4. Simulator Interactions:

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| Sr. No | What students will do? | What Simulator will do? | Purpose of the task |
| 1. | Change the length and speed as per required | Display the velocity and acceleration diagram along with the table containing, position, acceleration of each link and display arrow marks to proceed and Display length of each links and the angle theta | Recall the experiment and change the lengths to the desired values |
| 2 | Navigate to the next page using the arrows displayed | Display the acceleration at the CG | To obtain the acceleration at CG’s |
| 3 | Change to the required torque and angle theta and click next button | Display acceleration at CG and also provision to change the torque and angle, tabular column containing acceleration values | To obtain acceleration when torque is changed |
| 4 | Change the masses as required and click on arrow to proceed. | Display provision to change mass of each bars and display table containing the values of forces acting on each links | To change the masses of each bars and to get desired output |
| 5 | Navigate to the next page using the arrows displayed | Display the offset analysis animation and tabular column containing offset values | To observe the offset analysis |
| 6 | Navigate to the next page using the arrows displayed | Display the forces acting on each link and a tabular column containing each of the forces value. | To obtain the forces of each link and observe the changes when variables are changed |

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