Laboratory Manual

Theory of Machine Lab

List of Experiments:

1. To draw velocity diagram of slider crank mechanism.
2. To draw acceleration diagram of four bar mechanism.
3. To draw velocity diagram of slider crank mechanism.
4. Coriolli's component of acceleration

EXPERIMENT No: 1

AIM:

To draw velocity diagram of slider crank mechanism.

PROBLEM:

The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 r.p.m. The crank is 150 mm and the connecting rod is 600 mm long. Determine : 1. Linear velocity and of the midpoint of the connecting rod, and 2. angular velocity of the connectingrod, at a crank angle of 45° from inner dead centre position.

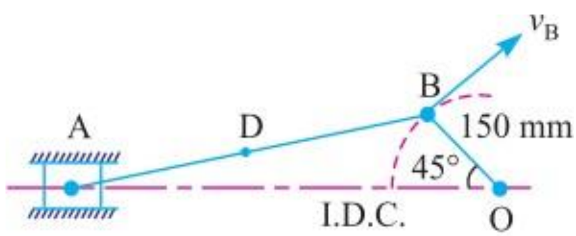
SOLUTION:

Given : N_{BO} = 300 r.p.m. or ω_{BO} = 2 π × 300/60 = 31.42 rad/s; OB = 150 mm =0.15 m ; BA = 600 mm = 0.6m.

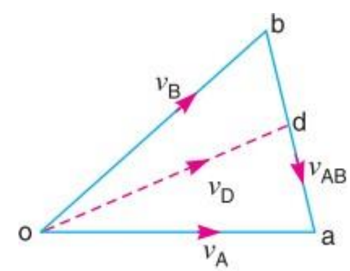
We know that linear velocity of B with respect to O or velocity of B,

$v_{BO} = v_B = \omega_{BO} \times OB = 31.42 \times 0.15 = 4.713$ m/s...(Perpendicular to BO)

Velocities in Slider Crank Mechanism



(*a*) Space diagram.



(*b*) Velocity diagram.

First of all draw the space diagram, to some suitable scale; as shown in Fig. Now the velocity diagram, as is drawn as discussed below:

1. Draw vector ob perpendicular to BO, to some suitable scale, to represent the velocity of B with respect to O or simply velocity of B i.e. v_{BO} or v_B, such that vector ob = $v_{BO} = v_B$ = 4.713 m/s.
2. From point b, draw vector ba perpendicular to BA to represent the velocity of A with respect to B i.e. v_{AB} , and from point o draw vector oa parallel to the motion of A (which is along AO) to represent the velocity of A i.e. v_A. The vectors ba and oa intersect at a.By measurement, we find that velocity of A with respect to B,

   v_{AB}=vector ba= 3.4 m / s

   and Velocity of A ,v_A= vector oa= 4 m / s.
3. In order to find the velocity of the midpoint D of the connecting rod A B, divide the vector ba at d in the same ratio as D divides A B, in the space diagram. In other words,

   bd / ba = BD/BA   Since D is the midpoint of A B, therefore d is also midpoint of vector ba.
4. Join od. Now the vector od represents the velocity of the midpoint D of the connecting rod i.e. v_D

   By measurement, we find that

   v_D = vector od = 4.1 m/s Ans.

CONCLUSION:

The velocity diagram of slider crank was drawn and analysed.

EXPERIMENT No: 2

AIM:

To draw acceleration diagram of four bar mechanism.

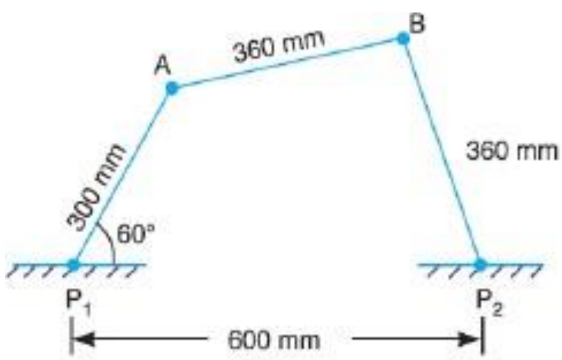
PROBLEM:

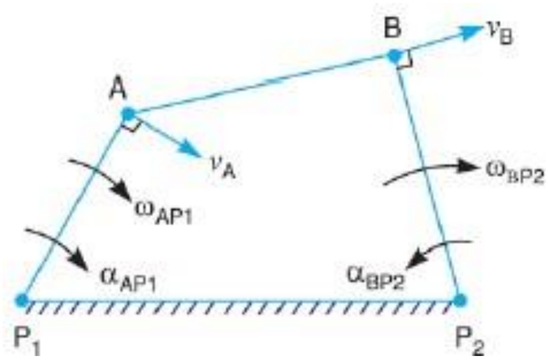
The dimensions and configuration of the four bar mechanism, shown in Figure, are as follows: P_1A = 300 mm; P_2B = 360 mm; AB = 360mm, and P_1P_2 = 600 mm. The angle AP_1P_2= 60°. The crank P_1A has an angular velocity of 10 rad/s and an angular acceleration of 30 rad/s^2, both clockwise. Determine the angular acceleration of P_2B, and AB and the velocity of the joint B.

SOLUTION:

Given : ω_{AP1} = 10 rad/s ; α_{AP1} = 30 rad/s^2; P_1A = 300 mm = 0.3 m ; P_2B = AB =360 mm = 0.36 m. We know that the velocity of *A* with respect to P_1 or velocity of *A,*

$V_{AP1} = V_A = \omega_{AP1} \times P_1A = 10 \times 0.3 = 3$ m/s.





VELOCITY DIAGRAM:

1. Choosing appropriate scale; draw vector ap (V_{AP1}=3 m/s).

2. Draw fixed point P_1& P_2 by single point in velocity diagram.

3. From point a, draw vector ab perpendicular to AB to represent velocity of B with respect to A.

4. From point P_2 draw vector P_2b perpendicular to P_2B to represent the velocity of B with respect to P_2 or velocity of B.

5. The vectors ab and p_2b intersect at b.

6. By measurement, we find that p_2b = 2.2 m/s

7. We know that angular velocity of P_2B,and angular velocity of AB:

$$\omega_{P2B} = \frac{v_{BP2}}{P_2B} = \frac{2.2}{0.36} = 6.1 \text{ rad/s (Clockwise)}$$

$$\omega_{AB} = \frac{v_{BA}}{AB} = \frac{2.05}{0.36} = 5.7 \text{ rad/s (Anticlockwise)}$$

ACCELERATION DIAGRAM:

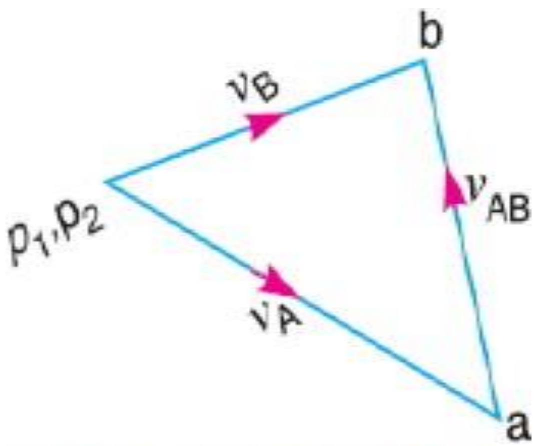
1. Since P_1 and P_2 are fixed points, therefore these points will lie at one place, in the acceleration diagram. Draw vector $p_1'x$ parallel to P_1A, to some suitable scale, to represent the radial component of the acceleration of *A* with respect to P_1.
2. From point *x*, draw vector *xa'* perpendicular to P_1A to represent the tangential component of the acceleration of *A* with

respect to P_1.

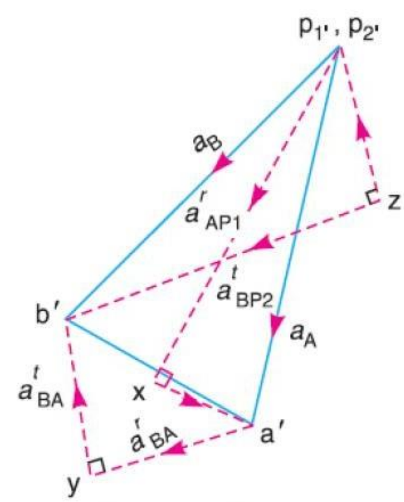
3. Join $p_1'a'$. The vector $p_1'a'$ represents the acceleration of A. By measurement, we find that theacceleration of A.
4. From point a', draw vector $a'y$ parallel to AB to represent the radial component of the accelerationof B with respect to A
5. From point y, draw vector yb' perpendicular to AB to represent the tangential component of theacceleration of B with respect to A
6. Now from point p'_2,draw vector p'_2z parallel to P_2B to represent the radial component of theacceleration B with respect to P_2.
7. From point z, draw vector zb' perpendicular to P_2B to represent the tangential component of theacceleration of B with respect to P_2.
8. The vectors yb' and zb' intersect at b'. Now the vector $p_2'b'$ represents the acceleration of B withrespect to P_2 or the acceleration of B.

$$\alpha_{P2B} = \frac{a^t_{BP2}}{P_2B} = \frac{26.6}{0.36} = 73.8 \text{ rad/s}^2 \text{ (Anticlockwise)}$$

$$\alpha_{AB} = \frac{a^t_{BA}}{AB} = \frac{13.6}{0.36} = 37.8 \text{ rad/s}^2 \text{ (Anticlockwise)}$$



VELOCITY DIAGRAM



ACCELERATION DIAGRAM

EXPERIMENT No: 3

AIM: To draw velocity diagram of slider crank mechanism.

PROBLEM:
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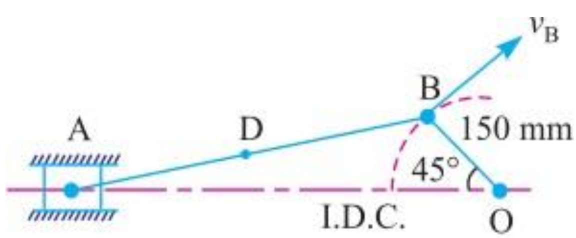
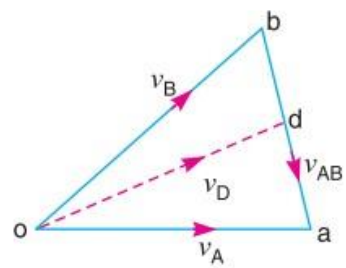


(a) Space diagram.



(b) Velocity diagram.

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   v_D = vector od = 4.1 m/s Ans.

CONCLUSION:
The velocity diagram of slider crank was drawn and analysed.

EXPERIMENT NO- 04

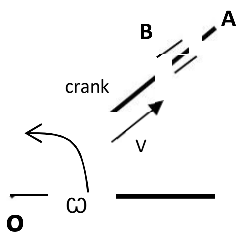
Name of Experiment- Coriolli's component of acceleration

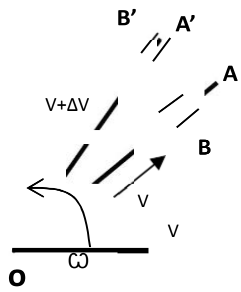
Objective: to find out velocity and acceleration of a moving point

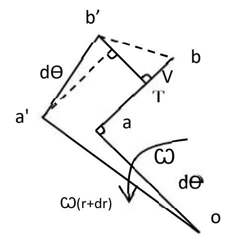
If a point is moving along a line, with the line having rotational motion, the absolute acceleration of the point, is vector sum of –ω.

i. Absolute acceleration of coincident point over the link relative to fixed center.
ii. Acceleration of point under consideration relative to coincident point and
iii. The third component, called Coriolis component of acceleration.

Theory: Consider the motion of slider 'B' on the crank OA. Let OA rotate with constant angular velocity of ω rad/s, and slider B have a radial outwards velocity V m/s relative to crank center 'O'.







In the velocity diagram, OA represents tangential velocity of slider at crank position OA, and ab represents radial velocity of slider, at same crank position, Oa' is the tangential velocity of slider at crank position OA and a'b' represents radial velocity of slider at same crankposition.

Hence, bb' represents the resultant the resultant change of velocity of slider. This velocity has two component b'T and bT in tangential and radial directions respectively.

Now,

Tangential component, b'T

(i)

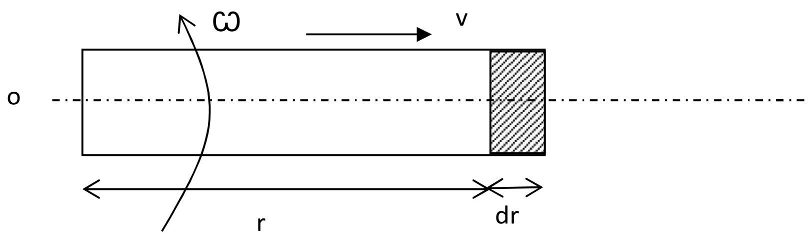
$$= b's + sT = V\sin d\theta + \omega\left(r + dr\right) - \omega r = Vd\theta + \omega dr$$

Therefore Rate of change of tangential velocity

$$= V\,d\theta + \omega\frac{dr}{dt} = V\omega + \omega V = 2\omega V\,dt \qquad \text{(ii)}$$

Equation (ii) represents coriolli's component of acceleration. This acceleration is made up of two components, one due to increase in radius and other from change in the direction of crank.

Hydraulic Analogy



Consider a short column of fluid of length dr at radius r from axis of rotation of the tube. Then, if velocity of fluid relative to tube is V and angular velocity of tube is ω then Coriolis component of acceleration is 2V ω in a direction perpendicular to rotation of tube. The torque dT applied by the tube to produce this acceleration is then

$$dT = \frac{dW}{g}.2V\omega r$$

Where, dW is weight of short column of fluid.

If w be the specific weight of fluid and a is cross sectional area of tube, then,

$$dW = wadr$$

$$dT = \frac{wadr}{g}2V\omega r$$

Total torque applied to column of length l,

$$T = \int_0^l 2\frac{w}{g}V\omega.a.r.dr = \frac{w}{g}wV.a.l^2$$

Hence, coriolli's component of acceleration, $\hat{C}\hat{A} = \dfrac{2gT}{wal^2}$ (iii)

Apparatus: The apparatus consists of two brass tubes connected to a central rotor distributor. The distributor is rotated by a variable speed d.c. motor. Water is supplied to a distributor by a pump through rotameter. When tubes are rotating with water flowing through tubes, with various measurements provided, coriollis's component can be determined experimentally and theoretically.

Specifications

1) Pipes- 7.7mm I.D. 329 mm. Effective length- 2Nos.
2) Drive motor 0.5 HP, 750 rpm d.c. series motor, swinging field type with speed control.
3) Torque arm- Radius 0.125 m with 5 Kg (capacity spring balance)
4) Pump- 05 HP, Rotameter 400 to 4000 liters per hour capacity.

Observation Table:

SL No	Torque (Kg-m)	Speed (RPM)	LPS
1	0.06	189	0.45
2	0.08	242	0.45
3	0.10	299	0.45

Calculations:

1) Bore dia. of tubes = 7.7 mm, Area of tube = 4.6566×10^{-5} m^2, Total flow area = 9.31325×10^{-5} m^2
2) Flow rate = Q = LPH/3.6×10^6 m^3/s, Velocity of water through the tubes, $V = \frac{Q}{a} m/s$
3) Length of torque arm = 0.125 m, T = (spring bal. diff.) ×0.125 Kg-m
4) Now theoretically, $CA = 2.V\omega = 2V\left(2\pi N/60\right)$ and Practically, $\hat{C}\hat{A} = \frac{2gT}{w.a.l^2}\ m/s^2$

Where, w = specific weight of water = 1000 Kg/m^3, l = Effective length of the tube = 0.329 m, a = Flow area of tube = 9.31325×10^{-5} m^2 and T = Torque in Kg-m.

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