Accelerations in Mechanism

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If velocity at various pts known.

acceleration of " " can be found -

IF Acc is known, external force $F = m \times a$.

can be calculated.

IF force is known - stresses developed at various pts can be calculated.

$\therefore$ stress due to accelerations. will be some time

> stresses developed by working load.

$a = \omega^2 r$. $\quad \underline{a \propto \omega^2}$

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If speed increases two times.

centripetal force will become four times

(ie) $F_c = \frac{mv^2}{r}$

Acceleration diagram are therefore fundamental to stress analysis of mechanism.

Acceleration

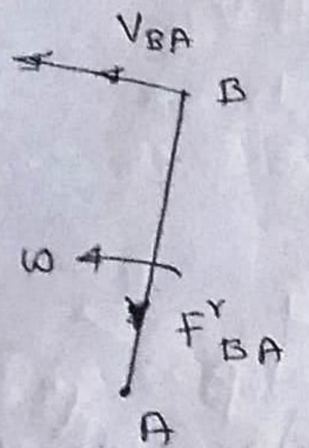
rate of change of velocity.

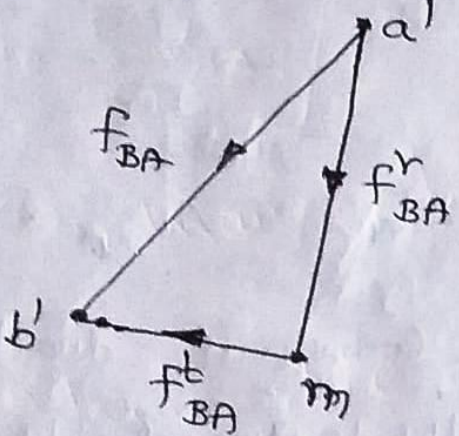
Acceleration diagram for a link

1) Analytical method.

2) Graphical method.

Acceleration diagram method





AB is rigid link.

pt-B moving w.r.t pt-A.

To find
Acceleration of B w.r.t. A.

Find acceleration of B assuming pt-A to be fixed.

If A is fixed., possible motion of B will be rotation.
abt pt.A.

Let ω = angular velocity of link AB.

α = angular acceleration of ''.

velocity of B changing in magnitude and direction.

acceleration of pt B will have 2 components.

1) radial component (centripetal component).

It is due to angular velocity.

acting along BA (||el to B.A),

directed from B towards A.

radial component = $\frac{V^2}{r} = \omega^2 \times r.$

$$F^r_{BA} = \frac{V_{BA}^2}{BA}$$

$$F^r_{BA} = \omega^2_{\cancel{BA}} \times BA.$$

2) Tangential Component due to (α) angular acceleration

It acts ||el to the velocity (or) $\perp r$ to AB.

magnitude of this component.

$$f^t_{BA} = \alpha \times BA$$

The total acceleration of B w.r.t A

is $$f_{BA} = f^r_{BA} + f^t_{BA}$$

$$= \frac{v^2_{BA}}{BA} + \alpha\, BA.$$

Acceleration Diagram for the link A-B

1) Take any point a' (Here fixed pt should be taken).

radial Component of acceleration is acting along B.A.

tangential Component $\perp$r B.A in direction of velocity.

From a' draw am llel to BA to represent radial component of accelaration. of B w.r.t A.

$$a'm = f^r_{BA} = a^r_{BA} = \frac{V^2_{BA}}{BA}$$

2) From pt m draw mb' ⊥r to A.B to represent tangential Component of acceleration B w.r.t A.

$$mb' = f^t_{BA} = a^t_{BA} = \alpha BA$$

3) Join $b'a'$

vector ~~ba~~ $\overline{a'b'}$ represents total acceleration of B w.r.t. A.

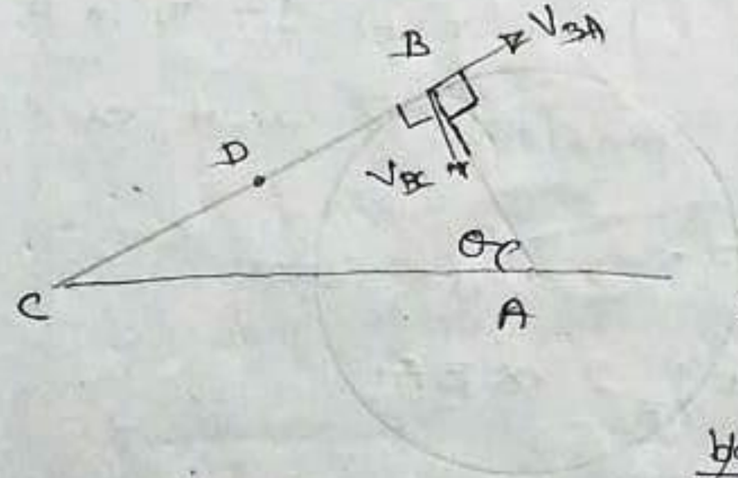
Note

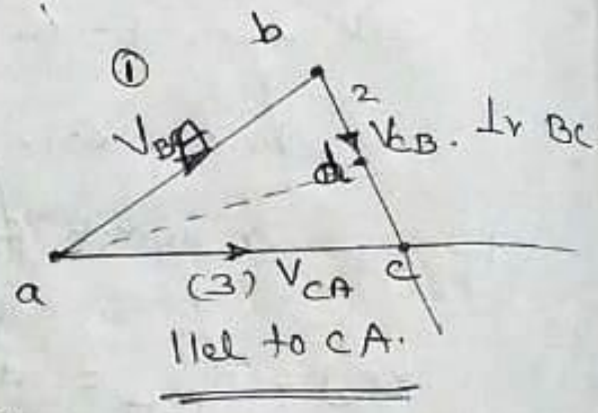
* small letters with a prime is used for acceleration diagram
* Lines from the common fixed points in acceleration diagram represents absolute accelerations.
* Abs acceleration $\rightarrow$ sum of $\underline{\underline{a_r}}$ and $\underline{\underline{a_t}}$.

Acceleration diagram for a slider crank mechanism

ab || V_{BA}

$\perp r$ BA





$\frac{bd}{bc} =$

$V_{BA} = V_B$ = velocity of B w.r.t. A. $V_{BA} = \overline{ab}$

$V_{CA} = V_c =$ " " C w.r.t. A $V_{CA} = V_c = \overline{ac}$

$V_{CB} = \overline{bc}$ = velocity of C w.r.t. B.

First draw velocity diagram

Take pt a as fixed point. ~~dor~~

draw $\overline{ab}$ ||el to velocity V_{BA}. to a

suitable scale ~~V~~

$$\boxed{V_{BA} = \omega \times BA}$$

V_{BC} ⊥r link BC.

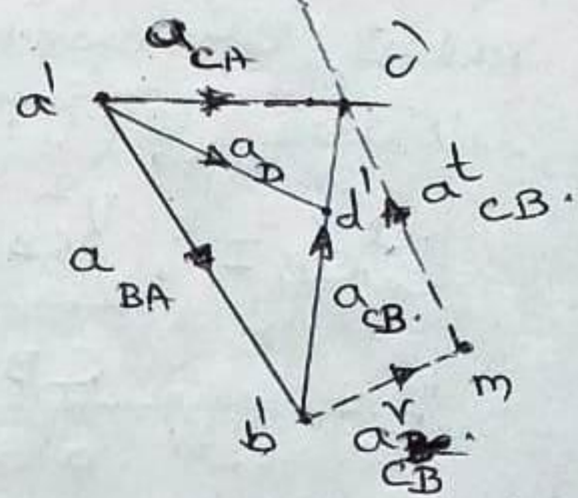
draw vector. $\overline{bc}$ ||el to V_{BC} (Infinite line)

draw line from a such that it intersects.
$\overline{bc}$ at a pt c

To find ~~any~~ velocity at any pt D,

divide vector bc such that.

$$\frac{bd}{bc} = \frac{BD}{BC},$$



Join. $\overline{ad}$
pts a,d

measure $\overline{ad}$ convert it to suitable scale.

to find velocity at any point.

To find acceleration diagram

Crank BA has radial component.

$$f^r_{BA} = a^r_{BA} = \frac{V_{BA}^2}{BA}$$

since it is rotating at constant angular velocity ω

angular acceleration. is $\alpha_{BA} = 0$.

$\therefore f^t_{BA} = a^t_{BA} = 0$.

resultant acceleration $a_{BA} = f_{BA} = a^r_{BA} + a^t_{BA}$

$$= a^r_{BA} = \frac{V^2_{BA}}{BA}$$

a_{BA} lies or acting along B·A.

draw a'b' ll to B·A. equal in magnitude

of a_{BA} to some suitable scale

For link $\underline{\underline{CB}}$ (connecting rod)

radial component of acceleration of C w.r.t B.

$$\boxed{a^{r}_{CB} = \frac{V^2_{CB}}{CB}}$$

It acts along CB.

tangential component of C w.r.t. B. ⊥r CB.

$$\boxed{a^{t}_{CB} = \alpha_{CB} \, CB}$$

used to find angular acceleration of ~~B~~.

C with respect to B.

$$f_{CB} = f^{r}_{CB} + f^{t}_{CB}.$$

$$a_{CB} = a^{r}_{CB} + a^{t}_{CB}.$$

V_{CB} obtained from velocity diagram.

from this

a^r_{CB} can be found.

Now for acceleration diagram.

(i) for a^r_{CB} with suitable scale draw vector $b'm$ ||el to CB

a^r_{CB} and a^t_{CB} ae $\perp r$.

From m draw a line $\perp r$ a^r_{CB} (or) $b'm$.

inorder to find resultant acceleration a_{CB}. (or)

$b'c'$

For line CA

At C moving in straight line w.r.t. line CA.

$\therefore$ radial component is zero.

But tangential component exists. It is in.

direction of C w.r.t. A.

But C moves about CA w.r.t. A.

$\therefore$ from a' draw a line ||el to CA.

It intersects a^t_{CB} at c'.

Join. $a'c'$

$b'c'$

from a^t_{CB}.

from diagram

angular acceleration. α_{CB} can be calculated

$a^t_{CB} = \alpha_{CB} \times CB$.

acceleration a_{CB} can be measured from scale.

acceleration a_{CA} " " " "

To find accelaration at any pt D.

$$\frac{b'd'}{b'c'} = \frac{BD}{BC}$$

mark d'

connect $a'd'$.

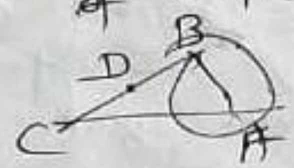
measure the line $a'd'$ to get the accelaration at pt D on connecting rod.

problem

The crank of a slider crank mechanism is 15 cm and the connecting rod is 60 cm long. The crank makes 300 rpm in the clock wise direction; when it has turned 45° from the inner dead centre position determine

(i) Acceleration of the mid point of the connecting rod -

2) angular acceleration of C.R.



data

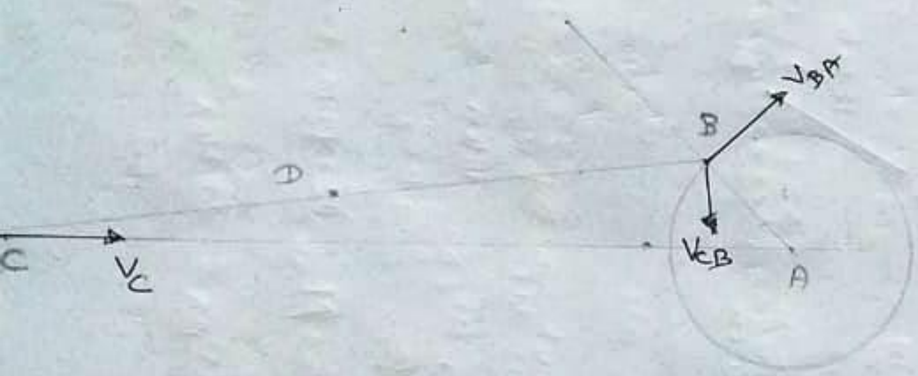
$r = AB = 15 cm$

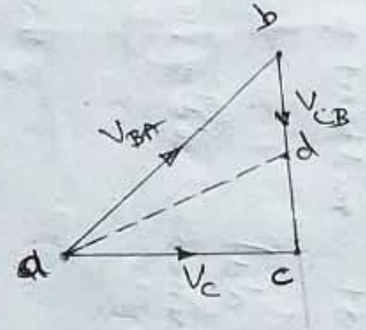
$l = BC = 60 cm.$

$N = 300$ rpm.

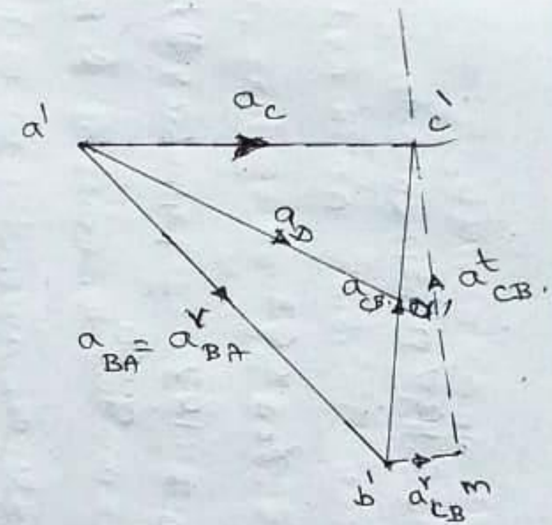
$\theta = 45°$. Find. acceleration at mid pt D

angular acceleration α_{BC}





velocity diagram



From velocity diagram. For acceleration diagram

$\omega_{BA} = \frac{2\pi N}{60} = 31.4 \text{ rad/sec}$

$V_c = \overline{ac} = 0.4 \text{ m/s}$

$V_{CB} = \overline{bc} = 0.34 \text{ m/s}$

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

$= 0.4712 \text{ m/sec.}$

Take scale $1 \text{ cm} = 0.1 \text{ m/sec}$

crank. No acceleration $a^t_{BA} = 0.$

$a^r_{BA} = \frac{V_B^2}{BA} = \frac{0.4712^2}{0.015} = 14.8 \text{ m/s}^2$

For C-R. $a^r_{CB} = \frac{V_{CB}^2}{CB} = \frac{0.34^2}{0.06} = 1.93 \text{ m/s}^2$

we need to find a^t_{CB} $a^t_{CB} \perp a^r_{CB}$.

By measurement $a^t_{CB} = \cancel{10.7}\ 10.3\ m/s^2$

$\therefore \quad a^t_{CB} = \alpha_{CB} \times CB$

angular acceleration. $\alpha_{CB} = \frac{10.3}{0.060} = 171.67\ rad/s^2$

To find acceleration at midpoint D of C-R.

draw vector $a'd'$

by measurement $a'd' = 11.7\ m/s^2$

Assignment and Self Practice

Assignment

The crank of a slider crank Engine 200 mm long and connecting rod length to crank radius is 4 - The crank has turned through 45^0 from inner dead Centre position. The instantaneous speed of rotation of the crank is 240 rpm - clockwise and it is increasing at the rate of 100 rad / s^2.

Determine,

1) acceleration of the midpoint of C.R.

2) angular acceleration of connecting rod,

3) acceleration of the slider.

Hint

Here crank will have tangential component and radial component both.

Here it doesnt rotate speed.

~~slider~~ crank accelerates Hence $a^t \neq 0$.

$\therefore a_{crank} = a^t_{crank} + a^r_{crank}$.

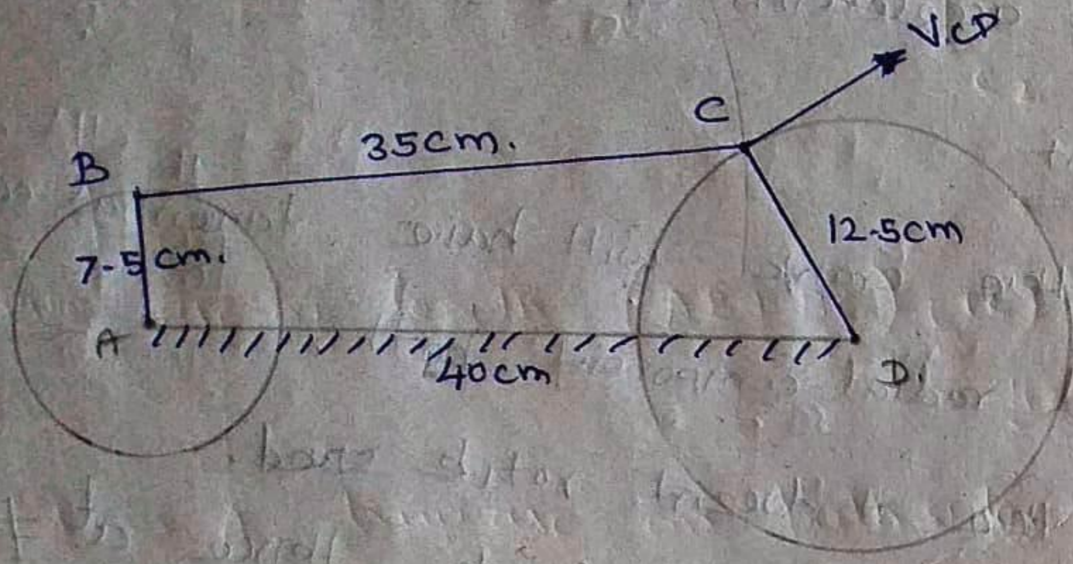
$a^t = 100 \text{ rad/s}^2$ $\quad a^r = \dfrac{V_{crank}}{\text{crank length (or) radius}}$

$\therefore$ extra tange & radial component comes.

A four bar kinematic chain is represented by a quadrilateral ABCD in which. AD is fixed is. 400 mm long. The crank AB 75 mm long. rotates in clockwise direction. at 120 rpm and drives. the link CD 125 mm long by means of link BC 350 mm long. 1) Determine angle through which C.D oscillates

2) Find angular velocities of the link B.C and C.D in one of the position when. B.C ⊥r AB.

<u>Scale</u> 1cm = 50 mm.



Find 1) angle through which C.D oscillates.

2) ω_{BC}, ω_{CD}. when BC $\perp$r AB.

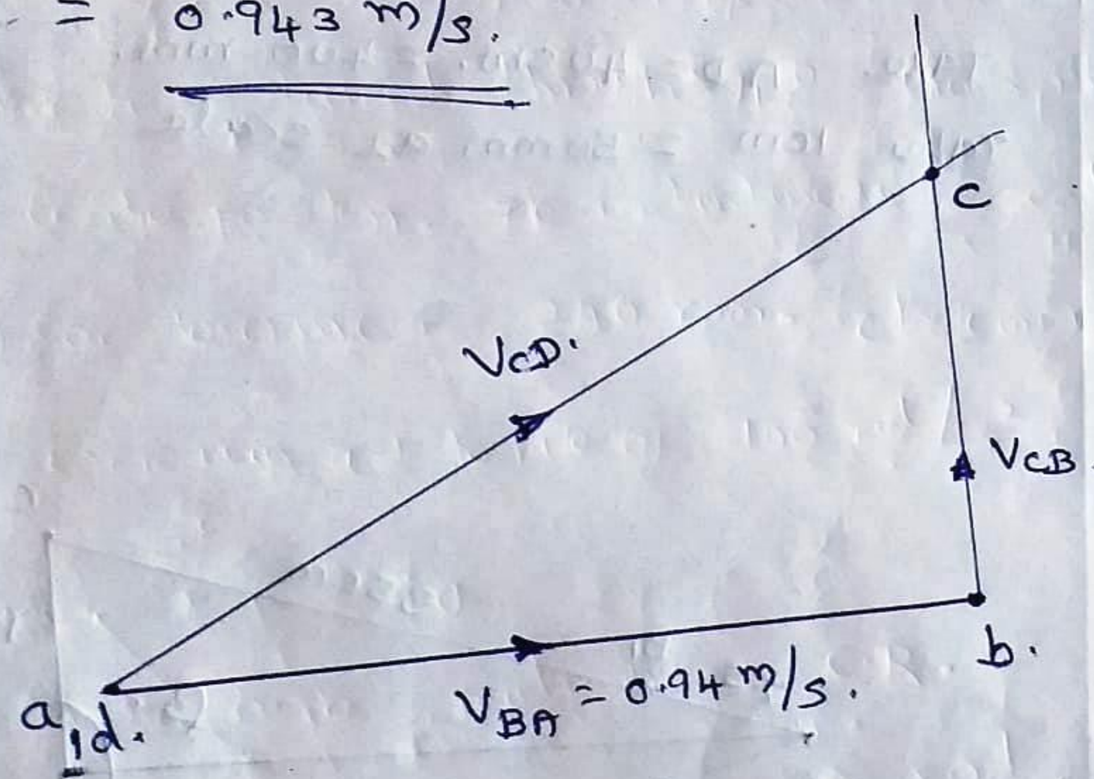
Soln data $N_{AB} = 120$ rpm.

$$\omega_{BA} = \frac{2\pi N_{BA}}{60} = 12.57 \text{ rad/s.}$$

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

$$= 12.57 \times 7.5 \text{ cm}$$

$$= \underline{0.943 \text{ m/s}}.$$



If BC $\perp$r AB.

V_{BA} pass through link BC.

V_{CB} $\perp$r to link CB.

||el to AB.

By measurement $V_{CB} = 0.3675$ m/s.

$V_{CD} = 1.008$ m/s.

$$\omega_{CB} = \frac{V_{CB}}{CB} = \frac{0.3675}{0.35} = 1.05 \text{ rad/s.}$$

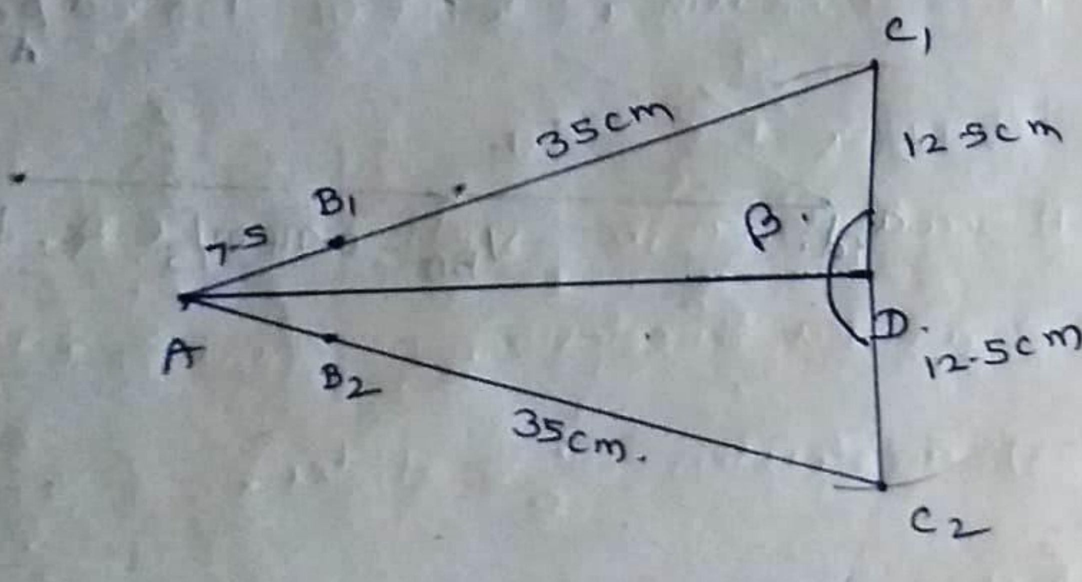
$$\omega_{CD} = \frac{V_{CD}}{CD} = \frac{1.008}{0.125} = 8.06 \text{ rad/s.}$$

(ii) Angle through which C.D oscillates.

Let β angle through which C.D oscillates.

Take AD = 40 cm. = 400 mm.

Take 1 cm = 50 mm as scale



Take arc of length (AB+BC). (i.e) (7.5+35)

42.5cm.

From A draw arc on both side.

from D draw arc having radius. 12.5 cm

measure angle β $\angle C_1DC_2$

by measurement ~~b~~ $\beta = 186^{0}$