Curvilinear system and Rectangular Coordinate System

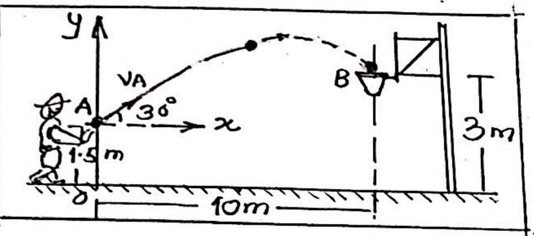
Path variables and Polar coordinates

Relative Motion

Curvilinear Motion , Rectangular Co-ordinate System

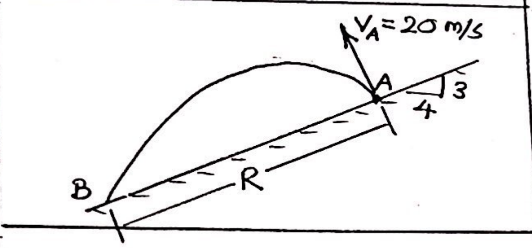
1 Determine the speed at which the basketball at A must be thrown at the angle of 30^0 so that it makes it to the basket at B.

Ans: u= 12.373 m



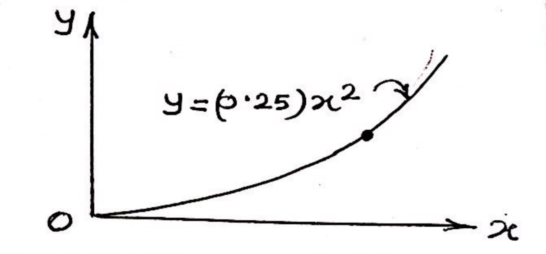
2 Water is sprayed at an angle of 90^0 from the slope at 20m/s. Determine the range R.

Ans: R=33.864 m



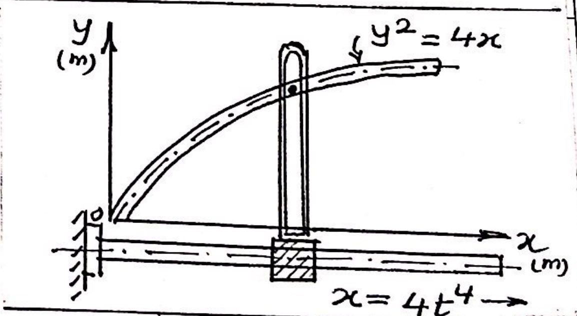
3 A particle is traveling along the parabolic path $y=0.25x^2$.If x=8m, V_x=8m/s, a_x=4 m/s^2 when t=2s, determine the magnitude of particle's velocity and acceleration at this instant.

Ans: v =32.985 m/s; a =48.2 m/s^2



4 A particle constraint to travel along the path. If x= $(4t^4)$m, where t is in seconds, determine the magnitude of particle's velocity and acceleration when t=0.5seconds.

Ans: v =4.472 m/s; a =14.422 m/s^2

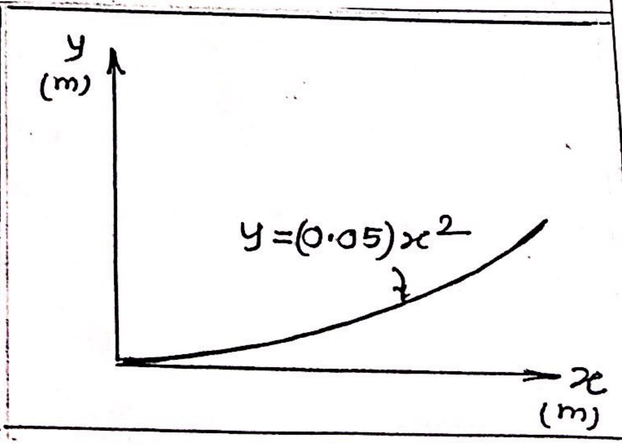


5 If x & y components of a particle's velocity are V_x=(32t) m/s, V_y=8m/s, determine the equation of the path y=f(x), if x=0 & y=0 when t=0.

Ans: y^2=4x

6 The box slides down the slope described by the equation y=$(0.05x^2)$m, where x is in meters. If the box has x component of velocity and acceleration of V_x= -3m/s and a_x= -1.5m/s^2 at x=5m, determine the y components of the velocity and the acceleration of the box at this instant.

Ans: V_y= -1.5m/s; a_y= 0.15m/s^2



Lecture No. 7

5 (1) RCH/F 12.15/pg. 661:

$V_x = (32)t = \frac{dx}{dt}$ $\qquad$ $V_y = 8 \text{ m/s} = \frac{dy}{dt}$

$\int_0^x dx = \int_0^t (32)t \cdot dt$ $\qquad$ $\int_0^y dy = \int_0^t 8 \cdot dt$

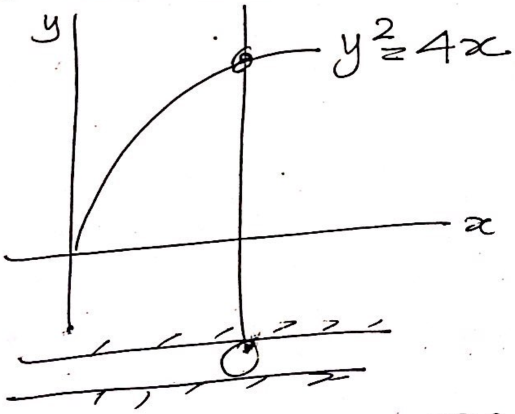
$x = 16 \cdot t^2 \longrightarrow (1)$ $\qquad$ $y = 8t \longrightarrow (2)$

$\therefore t = y/8$

$\therefore \quad x = 16 \times \frac{y^2}{64} = \frac{y^2}{4}$

Ans: $y^2 = 4 \cdot x$ or $\boxed{y = 2\sqrt{x}}$

4 (2) RCH/F 12.17/pg. 661:



$x = 4 \cdot t^4$ m

$\dot{x} = V_x = 16t^3$ m/s

$\ddot{x} = a_x = 48t^2$ m/s²

$y = 2\sqrt{x} = 4t^2$

$\dot{y} = 8t = V_y$ m/s

$\ddot{y} = a_y = 8$ m/s²

At $t = 0.5$ sec.

$V_x = 2$ m/s, $V_y = 4$ m/s $\qquad$ $V = 4.472$ m/s, $63.43°$

$\bar{V} = 2\hat{i} + 4\hat{j}$ m/s

$a_x = 12$ m/s², $a_y = 8$ m/s² $\qquad$ $a = 14.422$ m/s, $33.69°$

$\bar{a} = 12\hat{i} + 8\hat{j}$ m/s²

3 (3) RCH/F12.19/pg.661:

$y = (0.25)x^2$

At $t = 2$ s, $x = 8$ m

$V_x = \dot{x} = 8$ m/s

$a_x = \ddot{x} = 4$ m/s²

As, $y = (0.25)x^2$

Differenting w.r.t. x, we get,

$\dot{y} = (0.5)x\dot{x} = V_y$

$\ddot{y} = (0.5)\dot{x}^2 + (0.5)x\ddot{x}$

At $t = 2$ sec.: $V_x = 8$ m/s

$V_y = 0.5 \times 8 \times 8 = 32$ m/s

$V = \sqrt{8^2 + 32^2} = 32.985$ m/s

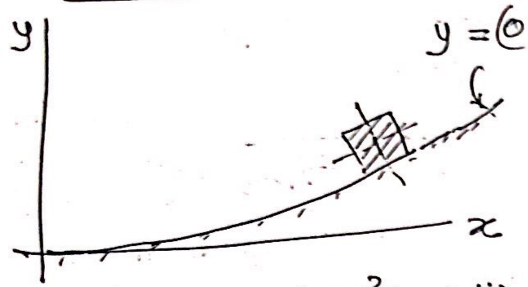
$a_x = 4$ m/s²

$a_y = (0.5 \times 64) + (0.5 \times 8 \times 4)$

$= 32 + 16 = 48$ m/s²

$a = \sqrt{4^2 + 48^2} = 48.2$ m/s²

6. (4) RCH/F12.20/pg.661



$y = (0.05)x^2$

At $x = 5$ m

$V_x = \dot{x} = -3$ m/s

$V_y = ?$

$a_x = -1.5$ m/s^2

$a_y = ?$

$$y = (0.05)x^2 \longrightarrow (i)$$

$$\therefore \dot{y} = (0.10)x\cdot\dot{x} \longrightarrow (ii)$$

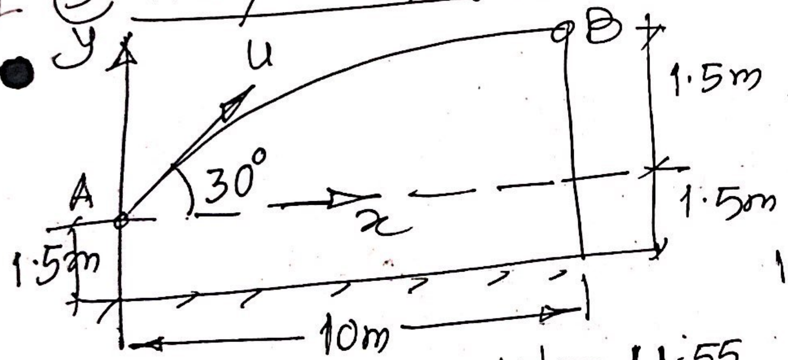
$$\ddot{y} = (0.10)\dot{x}^2 + (0.1)x\ddot{x} \longrightarrow (iii)$$

$\therefore$ At $x = 5$ m, $V_y = \dot{y} = 0.1\times5\times(-3) = -1.5$ m/s

i.e. 1.5 m/s (↓)

$$a_y = (0.10)(-3)^2 + (0.1)(5)(-1.5) = 0.15 \text{ m/s}^2 (\uparrow)$$

1. (5) RCH/F12.23/pg.662 :



$B \equiv (10\text{ m}, 1.5\text{ m})$

$$x = (u\cos\alpha)t$$

$$10 = (u\cos30^\circ)t \longrightarrow (1)$$

$$y = (u\sin\alpha)t - \frac{1}{2}gt^2$$

$$1.5 = (u\sin30^\circ)t - (4.905) \longrightarrow (2)$$

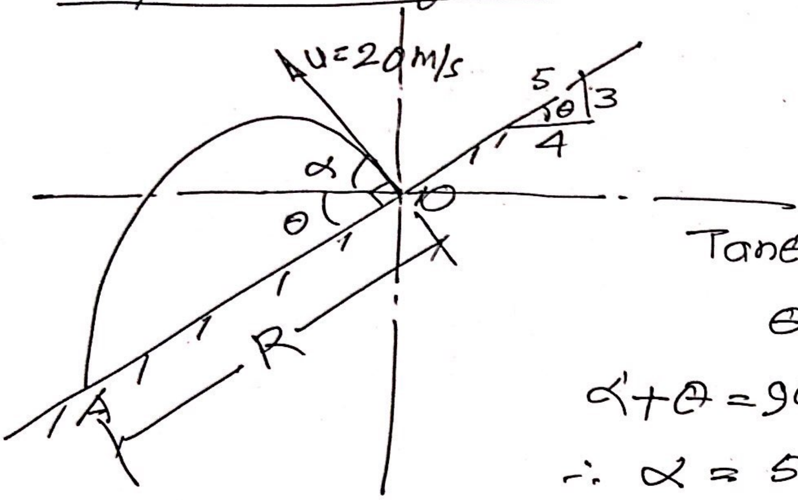
$$ut = 11.55 \quad \therefore u = \left(\frac{11.55}{t}\right)$$

$$y = \left(\frac{11.55}{t}\times0.5\times t\right) - (4.905)t^2$$

$$y = (5.773) - (4.905)t^2 = 1.5$$

$$t = 0.9334\text{ s}, \quad u = 12.373\text{ m/s}$$

2 6 RCH/F12·24/pg.662 :



$\tan\theta = \frac{3}{4}$

$\theta = 36.86^\circ$

$\alpha + \theta = 90^\circ$

$\therefore \alpha = 53.13^\circ$

At pt. A, $x = -R\cos\theta = -(0.8)R$

Eqns of projectile are, $y = -R\sin\theta = -(0.6)R$

$x = -(20)(\cos 53.13^\circ)t = -(12.0)\,t$ m/s $\rightarrow$ ①

$y = (20)(\sin 53.13^\circ)t - \frac{1}{2}(9.81)t^2$

$y = (16)t - (4.905)t^2 \longrightarrow$ ②

At A,

$x = -(0.8)R = -(12)t$

$\therefore \boxed{R = 15\cdot t}$

$y = 16\cdot t - (4.905)t^2 = -(0.6)R$

$16\cdot t - (4.905)t^2 = -9\cdot t$

$(4.905)t^2 - (25)t = 0$

$t = 2.257$ sec. 5.0968 sec.

$\therefore R = 33.864$ m 76.452 m

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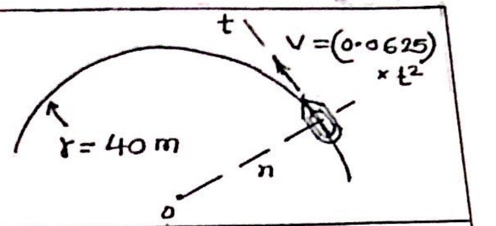
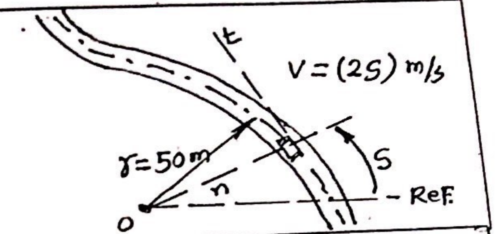
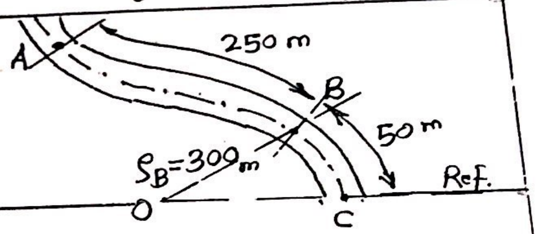
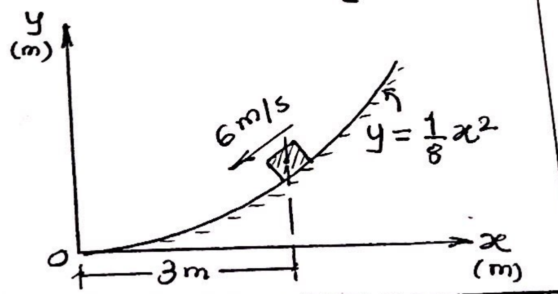
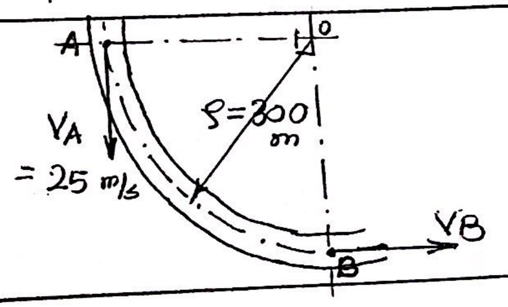
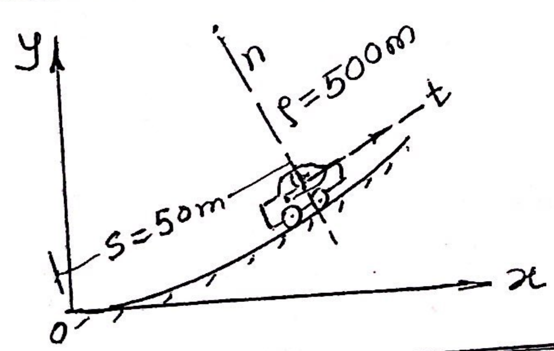
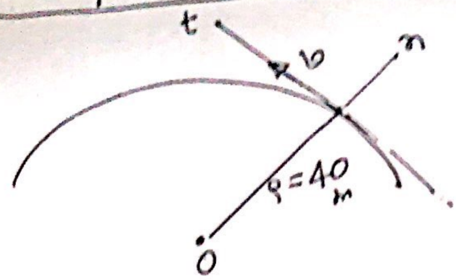
Lecture No:

Path Variables

1	The boat is traveling along the circular path with a speed of $v=(0.0625t^2)$m/s, where t is in seconds. Determine the magnitude of its acceleration when t=10s. **Ans: a=1.586 m/s^2**	
2	The car is traveling along the road with a speed of v=(2s)m/s, where s is in meters. Determine the magnitude of its acceleration when s=10m. **Ans: a= 40.792 m/s^2**	
3	If the car decelerates uniformly along the curved road from 25m/s at A to 15m/s at C, determine the acceleration of the car at B. **Ans: a_B= 1.178 m/s^2**	
4	When x=3m, the crate has a speed of 6m/s which is increasing at 2m/s^2. Determine the direction of the crate's velocity and the magnitude of the crate's acceleration at this instant. **Ans: a= 5.02 m/s^2**	
5	If the motorcycle has a deceleration of a_t = - (0.001s)m/s^2 and its speed at position A is 25m/s, determine the magnitude of its acceleration when it passes point B. **Ans: a_B = 1.423 m/s^2**	
6	The car travels up the hill with a speed of v=(0.2s)m/s, where s is in meters, measured from O Determine the magnitude of its acceleration when it is at point s=50m, where ρ=500m. **Ans: a= 2.01 m/s^2**	

Lecture No (8)

(1) RCH/F 12.27/ pg. 678 :



$V = (0.0625)t^2 \ m/s$

$\therefore a_t = \frac{dv}{dt} = (0.125)t \ m/s^2$

$\rho = 40 m$

$\therefore a_n = \frac{V^2}{\rho}$

At $t = 10 s$:

$V = 6.25 \ m/s, \quad a_t = 1.25 \ m/s^2$

$a_n = \frac{6.25^2}{40} = 0.9765 \ m/s^2$

$a = \sqrt{a_t^2 + a_n^2} = 1.586 \ m/s^2$

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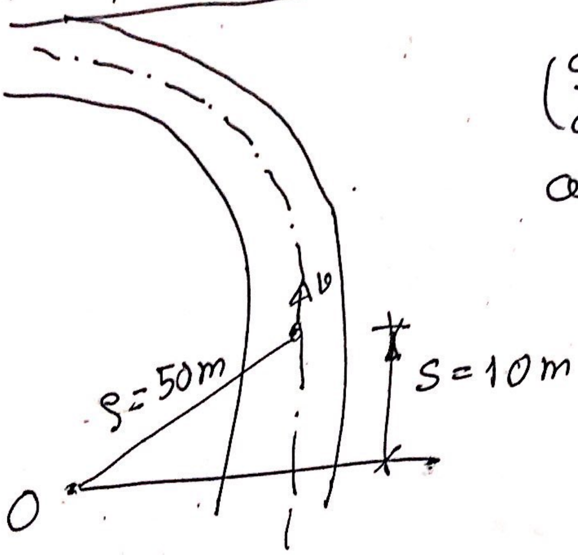
(2) RCH/F 12.28/ pg 678 :



$v = 2s \ m/s$

$\left(\frac{dv}{ds}\right) = 2$

$a_t = v.\frac{dv}{ds} = 4s \ m/s^2$

$a_n = \frac{V^2}{\rho} = \frac{4s^2}{50} \ m/s^2$

when $s = 10 m$

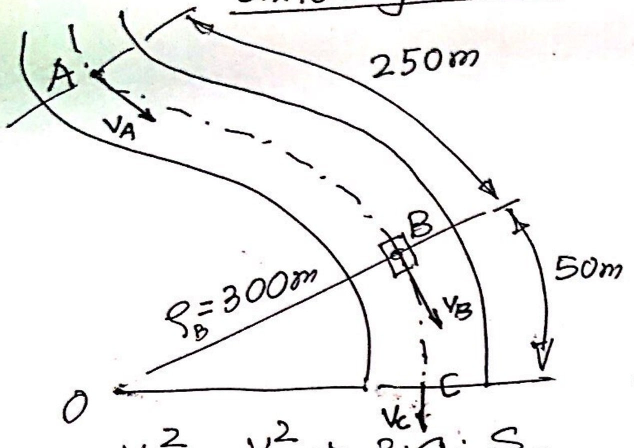
$a_t = 40 \ m/s^2$

$a_n = 8 \ m/s^2$

$a = \sqrt{a_t^2 + a_n^2} = 40.792 \ m/s^2$

(3) RCH/F 12.29/pg. 678 :

Uniformly accelerated curvilinear motion



$V_A = 25$ m/s

$V_C = 15$ m/s

$S_C = 300$ m

$V_C^2 = V_A^2 + 2 a_t S_C$

$15^2 = 25^2 + 2 \cdot a_t \cdot 300$

$\therefore \boxed{a_t = -0.666 \text{ m/s}^2}$

$V_B^2 = V_A^2 + 2 \cdot a_t \cdot S_B$

$= 25^2 - (2 \times 0.666 \times 250)$

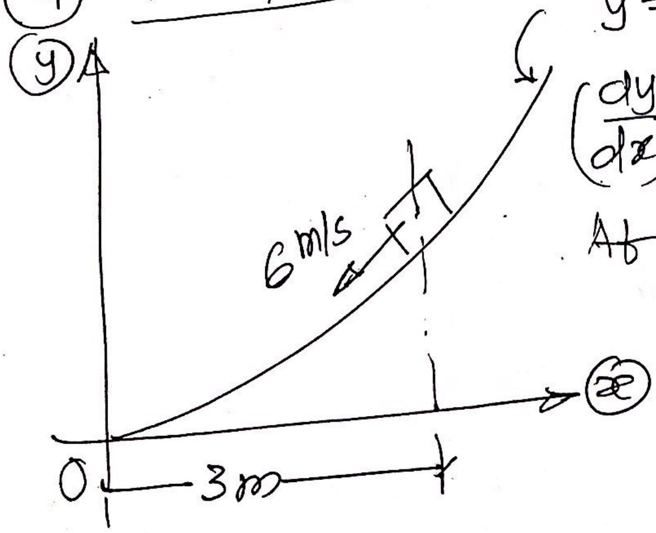
$\therefore V_B = 17.078$ m/s

$(a_n)_B = \dfrac{V_B^2}{\rho_B} = \left(\dfrac{17.078^2}{300}\right) = 0.972 \text{ m/s}^2$

$\therefore a_B = \sqrt{a_t^2 + a_n^2} = \sqrt{(-0.666)^2 + (0.972)^2}$

$\therefore a_B = 1.178 \text{ m/s}^2$

(4) RCH/F 12.30/pg. 678 :



$y = \frac{1}{8} \cdot x^2$

$\left(\dfrac{dy}{dx}\right) = y' = \dfrac{1}{4} x, \quad \left(\dfrac{d^2y}{dx^2}\right) = y'' = \dfrac{1}{4}$

At $x = 3$ m, $\left(\dfrac{dy}{dx}\right) = \dfrac{3}{4} = \tan\theta$

$\therefore \theta = 36.87^\circ$

$\rho = \left| \dfrac{\left[1 + (dy/dx)^2\right]^{3/2}}{d^2y/dx^2} \right| = \dfrac{(1 + 0.75^2)^{3/2}}{(1/4)}$

$\therefore \rho = 7.8125$ m

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$$a_n = \frac{V^2}{\rho} = \left(\frac{6^2}{7.8125}\right) = 4.608 \ m/s^2$$

$$a_t = 2 \ m/s^2$$

$$a = \sqrt{a_t^2 + a_n^2} = \sqrt{2^2 + 4.608^2} = 5.02 \ m/s^2$$

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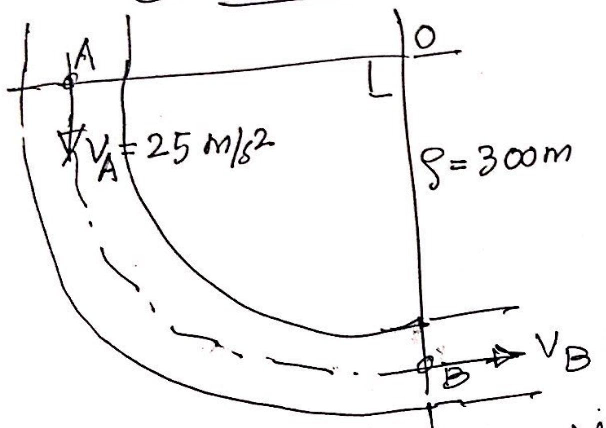
⑤ RCH/F 12.31/pg.678 :



$$a_t = -(0.001)s \quad m/s^2$$

At B, $s = \rho\theta = 300 \times \frac{\pi}{2}$

$$s = 471.238 \ m$$

$$(a_t)_B = -(0.001 \times 471.238)$$

$$= -0.4712 \ m/s^2$$

$$a_t \cdot ds = v \cdot dv$$

$$-\int_0^{471.238} (0.001) s \cdot ds = \int_{25}^{V_B} v \cdot dv$$

$$-(0.001)\left(\frac{471.238^2}{2}\right) = \frac{1}{2}\left(V_B^2 - 625\right)$$

$$V_B = 20.07 \ m/s$$

$$(a_n)_B = \frac{V_B^2}{\rho} = \left(\frac{20.07^2}{300}\right) = 1.343 \ m/s^2$$

$$\therefore a_B = \sqrt{(a_t)_B^2 + (a_n)_B^2} = \sqrt{(-0.4712)^2 + (1.343)^2}$$

$$\therefore a_B = 1.423 \ m/s^2$$

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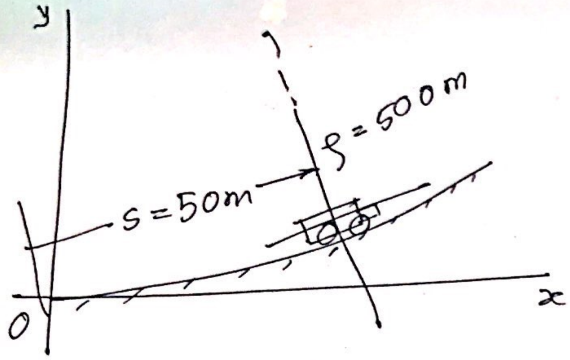
⑥ RCH/F12.32/~~pg~~.678 :



$$V = (0.2)s$$

$$a \cdot dx = v \cdot dv$$

Here, $a_t ds = v \cdot dv$

$$a_t = v \cdot \frac{dv}{ds} = (0.2 \times s)(0.2)$$

$$a_t = (0.04)s \quad m/s^2$$

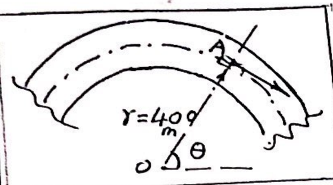
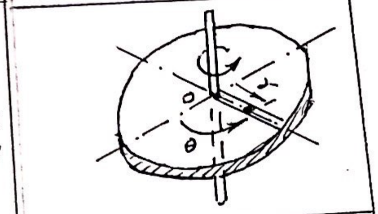
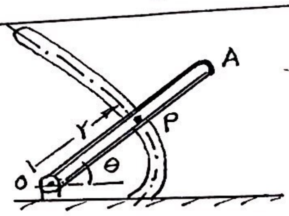
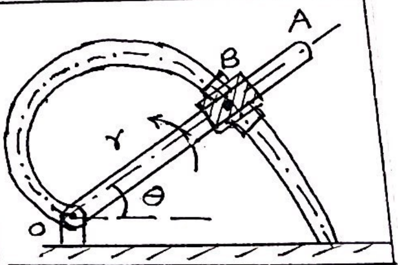
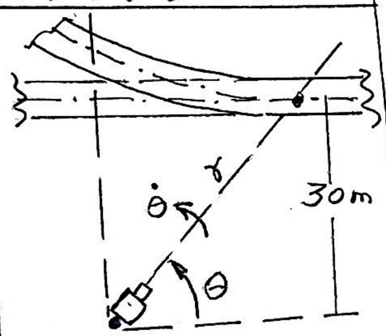
when $s = 50\,m$, $a_t = (0.04 \times 50) = 2\ m/s^2$

$$v = (0.2 \times 50) = 10\ m/s$$

$$a_n = \frac{v^2}{\rho} = \frac{10^2}{500} = 0.2\ m/s^2$$

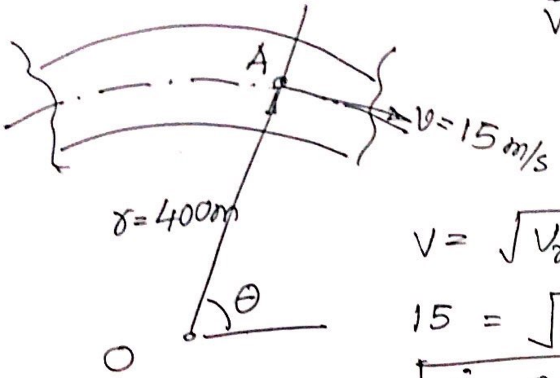
$$a = \sqrt{a_t^2 + a_n^2} = \sqrt{2^2 + 0.2^2}$$

$$= 2.01\ m/s^2$$

1	1) The car has a speed of 15m/s. Determine the angular velocity $\dot{\theta}$ of the radial line OA at this instant. **Ans: $\dot{\theta}$ = 0.0375 rad/s**	
2	The platform is rotating about the vertical axis such that at any instant its angular position is $\theta = (4t^{3/2})$rad, where t is in seconds. A ball rolls outward along the radial groove so that its position is $r = (0.1t^3)$m, where t is in seconds. Determine the magnitudes of the velocity and acceleration of the ball when t=1.5s. **Ans: v = 2.57m/s; a= 20.4 m/s^2**	
3	Peg P is driven by the fork line OA along the curved path described by $r = (2\theta)$m. At the instant $\theta = \pi/4$ rad, the angular velocity and angular acceleration of the link are $\dot{\theta}$ = 3 rad/s and $\ddot{\theta}$= 1 rad/s^2. Determine the magnitude of the pegs acceleration at this instant. **Ans: a= 39.5 m/s^2**	Q.No.3 and 4
4	Peg P is driven by the forked link OA along the path described by $r = e^{\theta}$, where r is in meters. When $\theta = \pi/4$ rad, the angular velocity and angular acceleration of the link are $\dot{\theta}$ = 2 rad/s and $\ddot{\theta}$= 4 rad/s^2. Determine the radial and transverse components of pegs acceleration at this instant. **Ans: a_r = 8.774 m/s^2; a_θ = 26.316 m/s^2**	
5	Collars are pin connected at B and are free to move along rod OA and the curved guide OC having the shape of a cardioid, $r = [0.2(1+\cos\theta)]$m. At $\theta = 30^0$, the angular velocity of OA is $\dot{\theta}$ = 3 rad/s. Determine the magnitude of the velocity of the collars at this point. **Ans:v = 1.16 m/s**	
6	2) At the instant $\theta = 45^0$, the athlete is running with a constant speed of 2 m/s. Determine the angular velocity at which the camera must turn in order to follow the motion. **Ans: $\dot{\theta}$ = 0.0333 rad/s**	

Lecture No. ( )

① F 12.33/RCH/ pg. 693



$\bar{V} = \dot{r}\hat{e}_r + r\dot{\theta}\hat{e}_\theta$

$V_r = \dot{r} = 0$

$V_\theta = r\dot{\theta} = 400 \cdot \dot{\theta}$

$V = \sqrt{V_r^2 + V_\theta^2}$

$15 = \sqrt{0 + (400 \cdot \dot{\theta})^2}$

$\therefore \boxed{\dot{\theta} = 0.0375 \text{ rad/s}}$

② RCH/F 12.34/ pg. 693

At $t = 1.5\,s$

$r = (0.1)t^3 = 0.3375\ m$

$\dot{r} = (0.3)t^2 = 0.675\ m/s$

$\ddot{r} = (0.6)t = 0.900\ m/s^2$

$\theta = 4 \cdot t^{3/2} = 7.348\ rad$

$\dot{\theta} = 6 \cdot t^{1/2} = 7.348\ rad/s$

$\ddot{\theta} = 3 \cdot t^{-1/2} = 2.449\ rad/s^2$

$V_r = \dot{r} = 0.675\ m/s$

$V_\theta = r\dot{\theta} = (0.3375 \times 7.348)$

$= 2.480\ m/s$

$V = \sqrt{V_r^2 + V_\theta^2}$

$= \sqrt{0.675^2 + 2.48^2}$

$\therefore \boxed{V = 2.57\ m/s}$

$a_r = (\ddot{r} - r\dot{\theta}^2) = (0.9 - 0.3375 \times 7.348^2)$

$= -17.325\ m/s^2$

$a_\theta = (r\ddot{\theta} + 2\dot{r}\dot{\theta}) = (0.3375 \times 2.449) + (2 \times 0.675 \times 7.348)$

$= 10.747\ m/s^2$

$a = \sqrt{a_r^2 + a_\theta^2} = \sqrt{(-17.325)^2 + (10.747)^2}$

$\therefore \boxed{a = 20.4\ m/s^2}$

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③ RCH/F 12·35/pg·693 :

$\gamma = 2\theta \qquad \dot{\theta} = 3 \text{ rad/s}$

$\dot{\gamma} = 2\dot{\theta} \qquad \ddot{\theta} = 1 \text{ rad/s}^2$

$\ddot{\gamma} = 2\ddot{\theta} \qquad \theta = (\pi/4) \text{ Rad}$

$\therefore \gamma = \left(2 \times \frac{\pi}{4}\right) = 1.57 \text{ m}$

$\dot{\gamma} = (2\times3) = 6 \text{ m/s}$

$\ddot{\gamma} = (2\times1) = 2 \text{ m/s}^2$

$a_\gamma = (\ddot{\gamma} - \gamma\dot{\theta}^2) = 2 - (1.57\times3^2) = -12.14 \text{ m/s}^2$

$a_\theta = (\gamma\ddot{\theta} + 2\dot{\gamma}\dot{\theta}) = (1.57\times1) + (2\times6\times3)$

$= 37.57 \text{ m/s}^2$

$a = \sqrt{a_\gamma^2 + a_\theta^2} = \sqrt{(-12.14)^2 + (37.57)^2}$

$\boxed{a = 39.5 \text{ m/s}^2}$

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④ RCH/F 12·36/pg·693

$\gamma = e^\theta \qquad \theta = \pi/4 \text{ rad}$

$\dot{\gamma} = (e^\theta)(\dot{\theta}) \qquad \dot{\theta} = 2 \text{ rad/s}$

$\ddot{\gamma} = (e^\theta)(\ddot{\theta}) + (e^\theta)(\dot{\theta}^2) \qquad \ddot{\theta} = 4 \text{ rad/s}^2$

$= e^\theta(\dot{\theta}^2 + \ddot{\theta}) \qquad \therefore \dot{\gamma} = 2 e^{\pi/4} = 2\times2.193$

$= 4.386 \text{ m/s}$

$\therefore a_\gamma = (\ddot{\gamma} - \gamma\dot{\theta}^2) = (17.546 - 2.193\times4) \qquad \ddot{\gamma} = e^{\pi/4}(4+4)$

$= 8.774 \text{ m/s}^2 \qquad = 17.546 \text{ m/s}$

& $a_\theta = (\gamma\ddot{\theta} + 2\dot{\gamma}\dot{\theta}) \qquad \gamma = e^{\pi/4} = 2.193 \text{ m}$

$= (2.193\times4 + 2\times4.386\times2)$

$= 26.316 \text{ m/s}^2$

⑤ RCH/F 12.37/ pg.693

$r = (0.2)(1+\cos\theta)$ m $\qquad \theta = 30^\circ = 0.5235^c$

$\dot{r} = -(0.2)(\sin\theta)\dot{\theta}$ m/s $\qquad \dot{\theta} = 3$ rad/s

$\ddot{r} = -(0.2)(\sin\theta)\ddot{\theta} + (\cos\theta)(\dot{\theta}^2)$ m/s²

when $\theta = 30^\circ$ $\quad r = 0.3732$ m

$\dot{r} = -0.3$ m/s

$V_r = \dot{r} = -0.3$ m/s

$V_\theta = r\dot{\theta} = (0.3732 \times 3) = 1.120$ m/s

$\therefore \quad V = \dot{r}\,\hat{e}_r + r\dot{\theta}\,\hat{e}_\theta$

$V = -(0.3)\hat{e}_r + (1.120)\hat{e}_\theta$ m/s

$V = \sqrt{(-0.3)^2 + (1.120)^2} = 1.16$ m/s

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⑥ RCH/F 12.38/ pg.693

$r = 30 \cdot \operatorname{cosec}\theta = \dfrac{30}{\sin\theta}$ $\qquad \theta = 45^\circ$, $\dot{\theta} = ?$

$\dot{r} = -30 \cdot \operatorname{cosec}\theta \cdot \cot\theta \cdot \dot{\theta}$

$\therefore$ when $\theta = 45^\circ = 0.7854$ rad

$r = 42.426$ m, $\quad \dot{r} = \dfrac{-30}{\sin 45^\circ} \times \dfrac{1}{\tan 45^\circ} \cdot \dot{\theta}$

$= -(42.426)\dot{\theta}$

$V_r = \dot{r} = -(42.426)\dot{\theta}$

$V_\theta = r\dot{\theta} = (42.426)\dot{\theta}$

$V = 2$ m/s $= \sqrt{V_r^2 + V_\theta^2}$

$2 = \sqrt{(-42.426\dot{\theta})^2 + (42.426\dot{\theta})^2}$

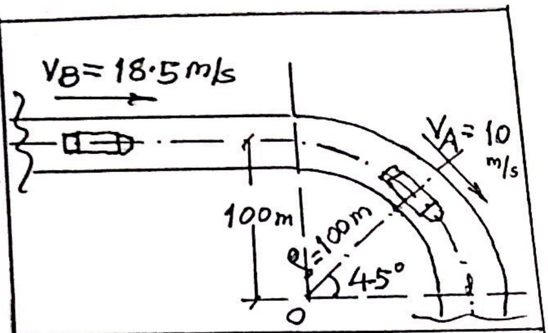
$\dot{\theta} = 0.0333$ rad/s

Lecture No:.

Relative Motion

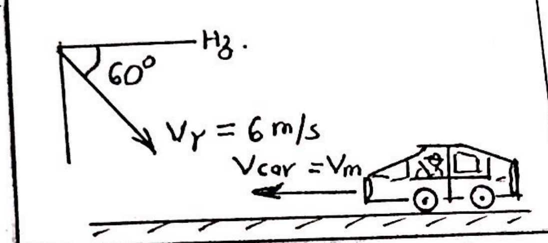
1 At the instant shown, the car at A is traveling at 10 m/s around the curve while increasing its speed at $5 m/s^2$. The car at B is travelling at 18.5 m/s along the straightway & increasing its speed at $2 m/s^2$. Determine the relative velocity & relative acceleration of A with respect to B at this instant.

Ans: $v_{A/B} = 13.44$ m/s, $A_{A/B} = 4.322 m/s^2$



2 The car is travelling at a constant speed of 100km/h. if the rain is falling at 6 m/s in the direction shown, determine the velocity of the rain as seen by the driver.

Ans: $v_{r/m} = 31.212$ m/s

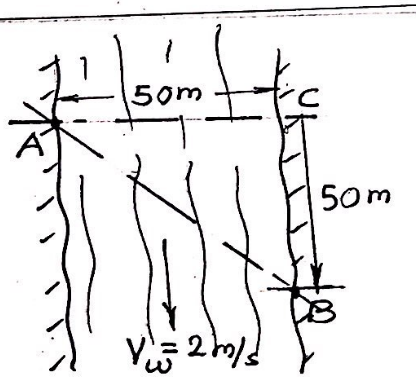


3 The car is travelling north along a straight at 50 kmph. An instrument in the car indicates that the wind is coming from the East. If the car's speed is 80kmph, the instrument indicates that the wind coming from north east. Determine the speed and direction of the wind.

Ans: V_w= - (30) i+ 50 j ; V_w= 58.309kmph

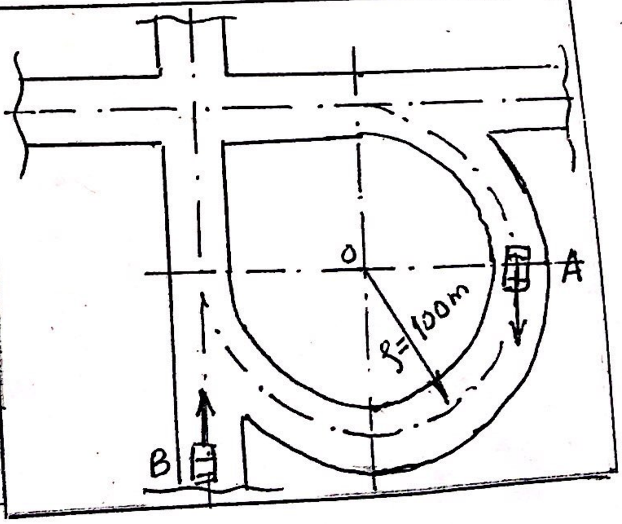
4 A man can row a boat at 5m/s in still water. He wishes to cross a 50-m-wide river to point B, 50 m downstream. If the river flows with a velocity of 2m/s, determine the speed the speed of the boat and the time needed to make the crossing.

Ans: V_{RB}= 6.21 m/s, t= 11.385 m/s



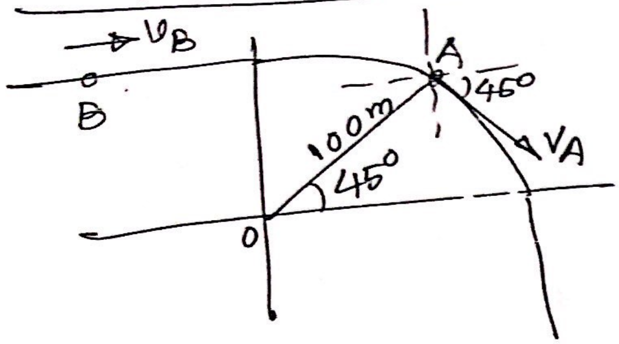
5 At the instant shown, car A has a speed of 20kmph, which is been increased at the rate of $300 km/h^2$ as the car enters the expressway. At the same instant, car B is decelerating at $250 km/h^2$ while travelling forward AT 100kmph. Determine the velocity & acceleration of A with respect to B.

Ans: $V_{A/B}$= -33.332 m/s = 0 kmph; $a_{A/B}$= $0.3085 m/s^2$



RCH/12.217/pg.715

1



$v_B = 18.5\ m/s \quad \therefore \bar{v}_B = (18.5)\hat{i}$

$a_B = 2\ m/s^2 \quad \therefore \bar{a}_B = (2.0)\hat{i}$

$V_A = 10\ m/s \ \searrow 45^\circ \quad \therefore \bar{V}_A = (7.07)\hat{i} - (7.07)\hat{j}\ m/s$

$a_A \Rightarrow (a_t)_A = 5\ m/s^2 \ \searrow 45^\circ$

$(a_n)_A = \frac{V^2}{\rho} = \frac{100^2}{100} = 1\ m/s^2 \ \swarrow 45^\circ$

$(\bar{a}_t)_A = (3.535)\hat{i} - (3.535)\hat{j}$

$(\vec{a}_n)_A = -(0.707)\hat{i} - (0.707)\hat{j}$

$\bar{a}_A = (2.828)\hat{i} - (4.242)\hat{j}\ m/s^2$

$\bar{V}_{A/B} = (\bar{V}_A - \bar{V}_B) = -(11.43)\hat{i} - (7.07)\hat{j}$

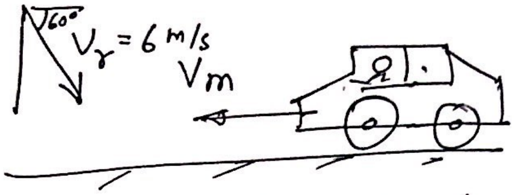
$31.74^\circ \quad V_{A/B} = 13.44\ m/s$

$\bar{a}_{A/B} = (\bar{a}_A - \bar{a}_B) = +(0.828)\hat{i} - (4.242)\hat{j}\ m/s$

$78.95^\circ \quad a_{A/B} = 4.322\ m/s^2$

RCH/12.219/pg.715 :

1



$$V_{man} = 100 \text{ kmph} = 27.777 \text{ m/s}$$

$$\bar{V}_m = -(27.777)\hat{i}$$

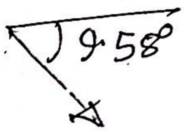
$$\bar{V}_{rain/man} = \bar{V}_{r/m} = \bar{V}_r - \bar{V}_m$$

$$V_{r/m} = (3)\hat{i} - (5.196)\hat{j} + (27.777)\hat{i}$$

$$\cancel{= (3)\hat{i} - (32.973)\hat{j} \text{ m/s}}$$

$$\cancel{84.8^\circ \quad V_{r/m} = 33.109 \text{ m/s}}$$

$$= (30.777)\hat{i} - (5.196)\hat{j} \text{ m/s}$$

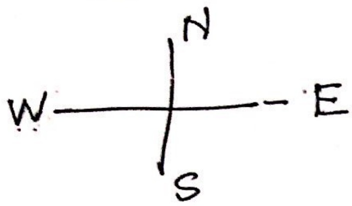


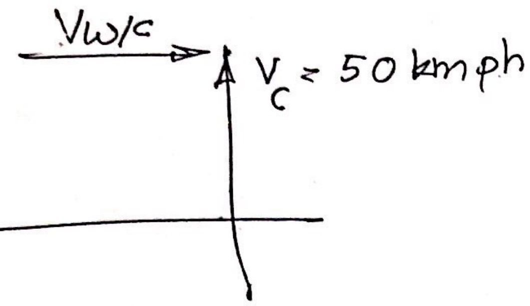
$$V_{r/m} = 31.212 \text{ m/s}$$

RCH/12.221/pg.716:

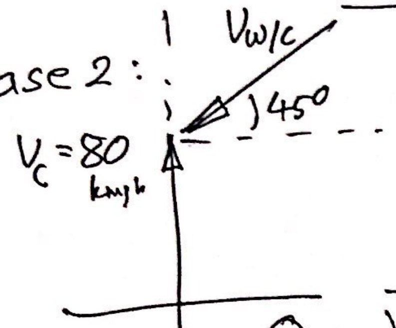
3

Case 1:





Case 2:



$$\bar{V}_{w/c} = \bar{V}_w - \bar{V}_c$$

$$\bar{V}_w = \bar{V}_{w/c} + \bar{V}_c$$

For case ① $\bar{V}_w = (V_{w/c_1})\hat{i} + (50)\hat{j}$

For case ② $\bar{V}_w = -(0.707 \times V_{w/c_2})\hat{i} - (0.707 \times V_{w/c_2})\hat{j} + 80\hat{j}$

Equating the coeff. of $\hat{i}$ & $\hat{j}$

$$(V_{w/c})_1 = -(0.707)(V_{w/c})_2 \longrightarrow ①$$

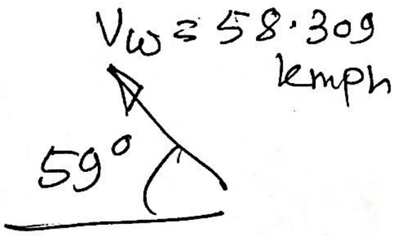
$$50 = -(707)(V_{w/c_2}) + 80$$

$$\therefore +30 = (0.707)(V_{w/c_2})$$

$$\therefore (V_{w/c})_2 = 42.432 \text{ m/s}$$

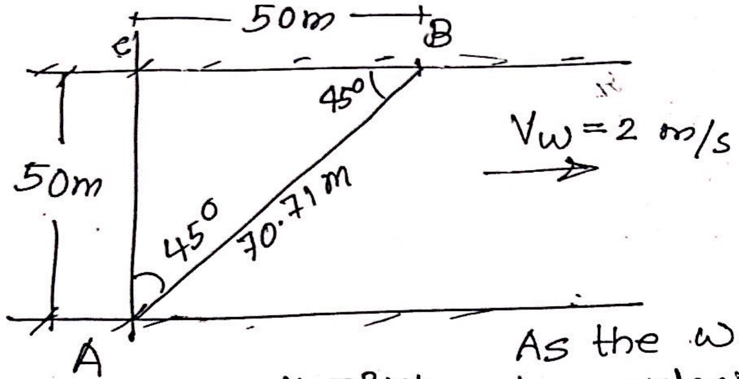
$$(V_{w/c})_1 = -30 \text{ m/s}$$

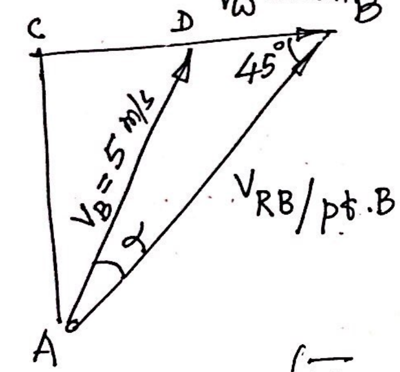
Ans: $\bar{V}_w = -(30)\hat{i} + (50)\hat{j}$



4

RCH/12.223/pg.716





As the water current has velocity of 2 m/s, boat can never cross the river in ⊥ direction. But, it will make some angle α, with the resultant velocity.

$$\bar{V}_{RB/pt.B} = \left(\bar{V}_{RB} - \cancel{\bar{V}_{pt.B}}\right) = \bar{V}_B + \bar{V}_w$$

But $V_{pt.B} = 0$

In ΔADB, $\dfrac{5}{\sin 45^\circ} = \dfrac{2}{\sin\alpha}$ $\therefore \alpha = 16.43^\circ$

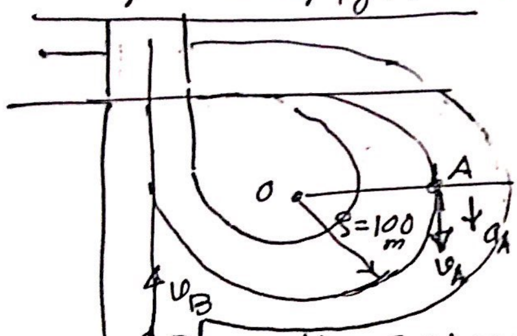
and $\dfrac{5}{\sin 45^\circ} = \dfrac{V_{RB}}{\sin(180^\circ - 45^\circ - 16.43^\circ)}$

$\therefore \boxed{V_{RB} = 6.21 \text{ m/s}}$

Time reqd. to cross the river & to reach pt. B, $t = \dfrac{70.71 \text{ m}}{6.21 \text{ m/s}} = 11.385$ sec.

RCH/12.225/pg.716 :

5



$V_A = 20 \text{ kmph} = 5.555 \text{ m/s}$

$(a_t)_A = 300 \text{ kmph}^2 = 0.023 \text{ m/s}^2$

$(a_n)_A = \dfrac{V_A^2}{\rho} = \left(\dfrac{5.555^2}{100}\right) = 0.3085 \text{ m/s}^2$

$V_B = 100 \text{ kmph} = 27.777 \text{ m/s}$

$a_B = 250 \text{ kmph}^2 = 0.019 \text{ m/s}^2$

$\therefore \quad \bar{V}_A = 0\cdot\hat{i} - (5.555)\hat{j} \text{ m/s}$

$\bar{V}_B = 0\cdot\hat{i} + (27.777)\hat{j} \text{ m/s}$

$\therefore \quad \bar{V}_{A/B} = (\bar{V}_A - \bar{V}_B) = -(33.332)\hat{j} \text{ m/s}$

i.e. [illegible]0 kmph (↓)

$\bar{a}_A = -(0.3085)\hat{i} - (0.023)\hat{j} \text{ m/s}^2$

$\bar{a}_B = 0\,\hat{i} - (0.019)\hat{j} \text{ m/s}^2$

$\therefore \quad \bar{a}_{A/B} = (\bar{a}_A - \bar{a}_B)$

$= -(0.3085)\hat{i} - (0.004)\hat{j} \text{ m/s}^2$

~~$a_{A/B} = 0.31134 \text{ m/s}^2$~~

~~$7.75°$~~

$0.74°$

$a_{A/B} = 0.3085 \text{ m/s}^2$