Notre Dame University. Department of Mechanical Engineering

Test #1-MEN101 (Dynamics) *Closed book:60 minutes*

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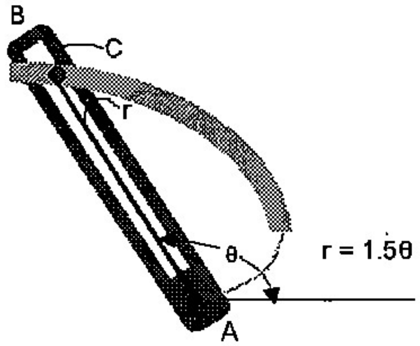
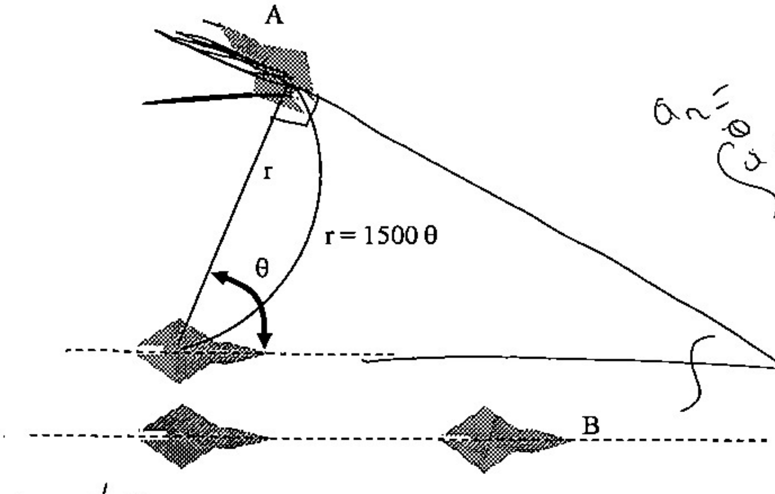
Problem # 1(50pts)

The slotted arm AB drives the pin C through the spiral groove described by the equation $r = (1.5\theta)$ ft, where θ is in radians. If the arm starts from rest when $\theta = 60^0$ and is driven at an angular rate $\dot{\theta} = (4t)$ rad/s, where t is in seconds, determine the radial and θ of velocity and acceleration of the pin when t = 1s.



Problem # 2(50pts)

Two rockets A and B are flying side by side at a constant speed of 900 km/hr. Maintaining this speed, rocket A begins to travel along the spiral path $r = (1500\ \theta)$ km, where θ is in radians, whereas rocket B continues to fly in a straight line. Find the speed of rocket A with respect to rocket B when r = 750 km.



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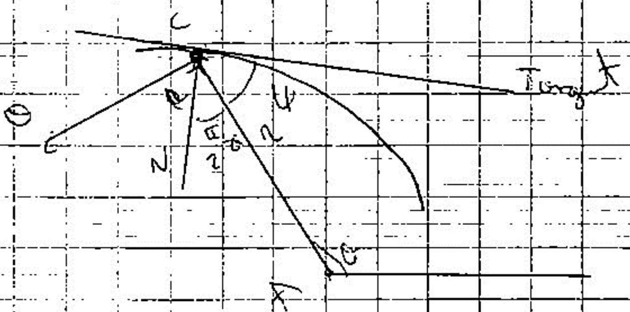
Grade: 55

Course: MEN-101 Section: B Date: 16-3-2006.

Problem #1:



let's first find ψ: $\tan\psi = \frac{r}{dr/d\theta} = \frac{1.5\theta}{1.5} = \theta$ rad

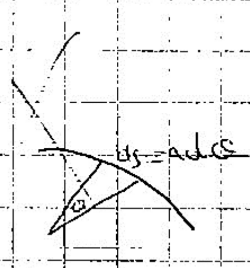
~~cot θ~~

~~$\Sigma F_r = ma_r \Rightarrow N\cos\left(\frac{\pi}{2} - \theta\right) =$~~ $\dot\theta = ct \;/\; \dot\theta = 4$ rad/s

$\ddot\theta = 4$ rad/s²

$V_r = \dot r = 1.5\dot\theta = 4 \times 1.5\theta = 6\theta$ ft/s

$V_\theta = r\dot\theta = 1.5\theta \times 4$



$a\,ds = v\,dv$

~~$a = \frac{v\,dv}{r\,d\theta}$~~

$\Rightarrow a \times 1.5\theta \times d\theta = v\,dv \qquad v = 6\theta$

$a_\theta = r\ddot\theta + 2\dot r\dot\theta$

$= 1.5\theta \times 1 + 2 \times 1.5 \times \theta \times \dot\theta^2$

$= 1.5\theta + 4.5\theta \times 16 = 73.5\theta$

$\Rightarrow 73,50 \times 1,50\, d\theta = 60\, dV$.

$\Rightarrow \int_{60^\circ = \frac{\pi}{3}}^{\theta} 18,375\, \theta\, d\theta = \int_0^{60} dV$

$\Rightarrow 18,37 \times \frac{\theta^2}{2} = 60$.

$\frac{18,37 \times \theta^2}{2} - 18,37 \times \frac{\pi^2}{18} = 60$.

$\Rightarrow 9,875\, \theta^2 - 10,07 - 60 = 0$.

$\theta^2 - 1,096\, \theta - 0,653 = 0$

$\Rightarrow \theta = 1,52\, rad = 87^\circ$.

20

$\Rightarrow v_r = 1,52 \times 6 = 9,12\, ft/s$.

$v_\theta = 9,12\, ft/s$.

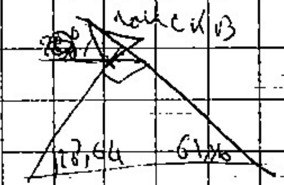
$a_r = \ddot{r} - r\dot{\theta}^2 = 1,5\dot{\theta}\dot{\theta} + 1,50\,\ddot{\theta} - r\dot{\theta}^2 = 8,8\, ft/s^2$.

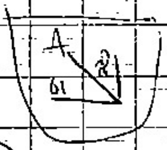
$a_\theta = 73,5 \times 1,52 = 111,42\, ft/s^2$.

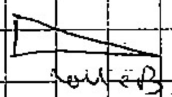
Problem #2: rocket A:

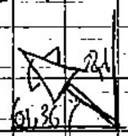
~~$V_\theta = r\dot{\theta} = 900\,km/h$~~

when $r = 750\,km$: $\theta = \frac{750\,km}{1500\,km} = 0,5\,rad = 28,64^\circ$

=> 





=> 

~~$V_\theta = r\dot{\theta} = 500 \times 0,5 \times \frac{A}{1500}$~~

=> $V_{\theta A} = r\dot{\theta} = 900$ => $\dot{\theta} = \frac{900}{750} = 1,2\,rad/s$

=> $V_{rA} = \dot{r} = 1500\,\dot{\theta} = 1500 \times 0,5 \times 1,5$

$= 900\,km/h$

=> $V_A = 900\cos 61,36^\circ\, i + 900\cos 28,64^\circ\, j$

and $V_{AB} = 900\, i$.

$$\vec{V}_{A/B} = V_A - V_B$$

$$= (900 \cos 61{,}34 + 900)\, i + j\,(900 \cos 28{,}66)$$

$$= 468{,}4\, i + 792{,}42\, j$$

~~mag $\vec{V}_{A/B} = \sqrt{468{,}4^2 + 792{,}42^2} = 443{,}3$ km/hr~~

$$= \sqrt{468{,}4^2 + 792{,}42^2} = 929{,}5 \text{ km/hr}$$

$h = 0 + 15{,}97\,t - \frac{1}{2}\,9{,}81\,t^2$

$2 = 0 + 0\,t - \frac{1}{2}(9{,}81)\,t$

$5 \times 9{,}81 \times 10^{-3} \times 3 = \frac{1}{2}\, 5\times10^{-3}\, v_B^2 + 5\times2\times10^{-3}\times9{,}81$

$0{,}1445$

$-17{,}56603812$

15,97

$10^{-3} \times 5 \times 9{,}81 \times 3 = \frac{1}{2} \times 5\times10^{-3}\, v_B^2$

$-\frac{1}{2} \times 500 \times (0{,}08)^2 + \frac{1}{2} \times 500 \times S^2 - 0{,}5 \times 9{,}81 \times (1{,}5 + 1{,}5 \cos 45)$

$(S_B + S_A + \ldots) \times 20$

$\frac{1}{2}\, m v_1^2 = \frac{1}{2}\, m v_2^2 + \ldots \cos 30 \times 3$

$\frac{1}{2} \times 0{,}7 \times 4^2 = \ldots \frac{1}{2} \times 2 \times 0{,}77 + \frac{1}{2}\, m v^2$

$\sqrt{(4 + 0{,}75)^2 - 0{,}75}\; 4$

$0{,}3 - 5{,}4 = 9{,}6$

1109,60