Solution

ME 274 Dynamics - 4:30 Lecture – Quiz 1: Chapter 1 point Kinematics review

Problem 1: Consider the path description for the motion of point P. circle **all statements** that correctly describe the acceleration of point P, $\vec{a}_p$.

a) The rate of change of speed for P, $\dot{v}_p$ is ALWAYS the same as the magnitude of its acceleration, $|\vec{a}_P|$.
b) The rate of change of speed for P, $\dot{v}_p$, is the same as the magnitude of its acceleration $|\vec{a}_P|$ if the path of P is straight.
c) The acceleration of point P is always PERPENDICULAR to the path of P
d) The rate of change of speed for P, $\dot{v}_p$, is the same as the magnitude of its acceleration $|\vec{a}_P|$ if the particle is at rest.
e) None of the above.

c) false. only perpendicular if the object is turning but not changing in speed

Hint: remember $\vec{a} = \dot{v}\hat{e}_t + \frac{v^2}{\rho}\hat{e}_n$ in the path description

$|\vec{a}|^2 = \dot{v}^2 + \left(\frac{v^2}{\rho}\right)^2$

a) false → if the component in the normal direction, $\frac{v^2}{\rho} \neq 0$, then $\dot{v}_p \neq |\vec{a}_p|$

b) if the path is straight, radius of curvature $\rho = \infty$
$\Rightarrow \frac{v^2}{\infty} = 0$ & $|\vec{a}| = \dot{v}$ $\boxed{\text{True}}$

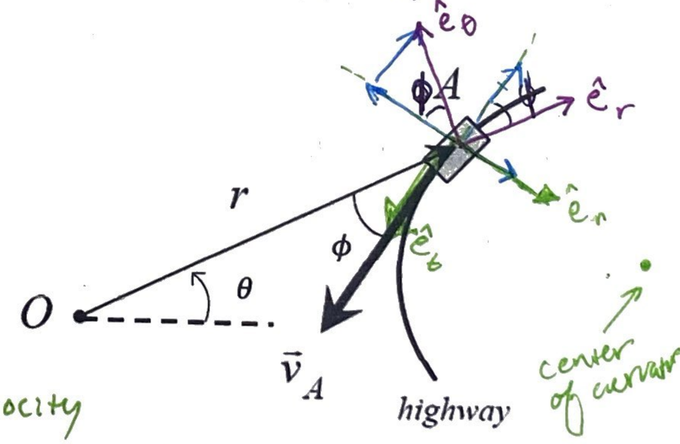
d) True - if the object is at rest, $v = 0$
so $|\vec{a}| = \dot{v}$

Problem 2: An automobile A travels along a highway with a speed of v_A. A police officer at point O is observing the motion of the car using a hand-held radar device. For this problem, express the polar unit vectors $\hat{e}_r, \hat{e}_\theta$ in terms of the path unit vectors $\hat{e}_t, \hat{e}_n$.

(a) $cos\phi$ (b) $-cos\phi$ (c) $sin\phi$ (d) $-sin\phi$

1) $\hat{e}_r = \underset{b}{-\cos\phi}\,\hat{e}_t + \underset{c}{\sin\phi}\,\hat{e}_n$

2) $\hat{e}_\theta = \underset{d}{-\sin\phi}\,\hat{e}_t + \underset{b}{-\cos\phi}\,\hat{e}_n$



unit vector reminder:
draw on the moving pt.
path coords: $\hat{e}_t$ in the direction of velocity
$\hat{e}_n$ in towards the center of curvature
polar coords: $\hat{e}_r$ points outwards in the direction of position vector
$\hat{e}_\theta$ points in the direction of increasing θ

Questions like this want you to break your vector into components.
Ask: How much of this vector points in this direction?

Vector projection help

If you are asked to translate between a Given coord. system and a target coord. system, ask

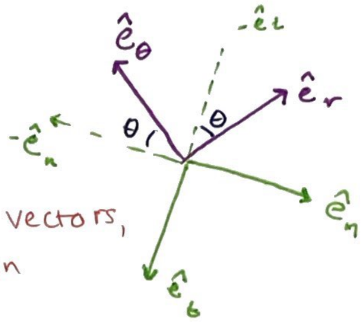
"How much of each target unit vector points in the direction of each given unit vector?"

To visualize this, think of vector projections as shadows of your target unit vector cast on your given unit vector

Ex: if we want to write $\hat{e}_r, \hat{e}_\theta$ in terms of $\hat{e}_t, \hat{e}_n$

$\hat{e}_r = \_\_\hat{e}_t + \_\_\hat{e}_n$

$\hat{e}_\theta = \_\_\hat{e}_t + \_\_\hat{e}_n$



note: all these vectors are unit vectors with a Length of 1!

we aren't changing the $\hat{e}_r$ & $\hat{e}_\theta$ vectors, we are simply expressing them in terms of components

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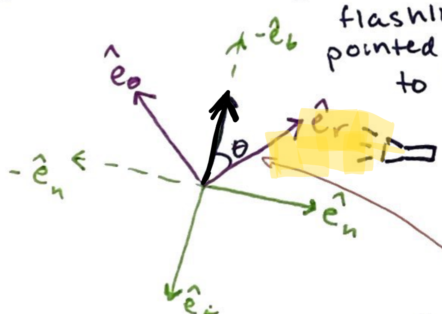
to find the component of $\hat{e}_r$ in the $\hat{e}_t$ direction, imagine shining a flash light onto the $\hat{e}_t$ axis (i.e. the flashlight is pointed perpendicular to $\hat{e}_t$)

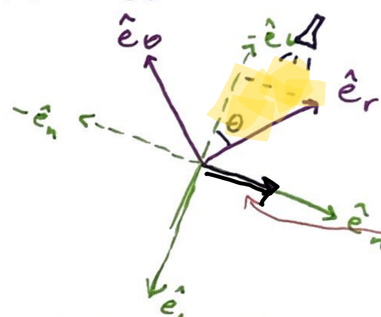


This is what the shadow of the $\hat{e}_r$ vector would look like. notice the shadow vector is adjacent to our angle and is in the $-\hat{e}_t$ direction

→ the component of e_r in the $\hat{e}_t$ direction is

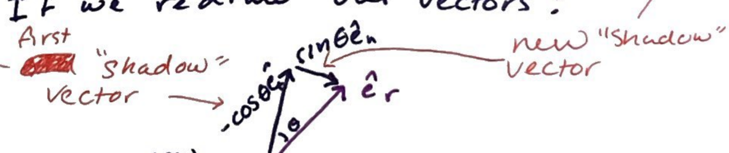
$\boxed{-\cos\theta\, e_t}$

to find the component of $\hat{e}_r$ in the $\hat{e}_n$ direction, move your flash light to shine on the $\hat{e}_n$ unit vector



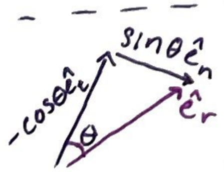
This is what the shadow of the $\hat{e}_r$ vector would look like on the $\hat{e}_n$ axis

If we redraw our vectors:



note this new vector is opposite our angle and is on the positive $\hat{e}_n$ direction

→ the component of $\hat{e}_r$ in the $\hat{e}_n$ direction is $\boxed{\sin\theta\,\hat{e}_n}$



graphically adding these vectors, you can see that $\hat{e}_r = -\cos\theta\,\hat{e}_t + \sin\theta\,\hat{e}_n$

repeating the process for $\hat{e}_\theta$: $\hat{e}_\theta = -\sin\theta\,\hat{e}_t - \cos\theta\,\hat{e}_n$

Problem 3: Blocks A and B are connected by and inextensible cable. Block A moves downwards with a speed of v_A. Let v_B be the speed of block B when $s_A > 0$. Circle the true statements describing v_A and v_B.

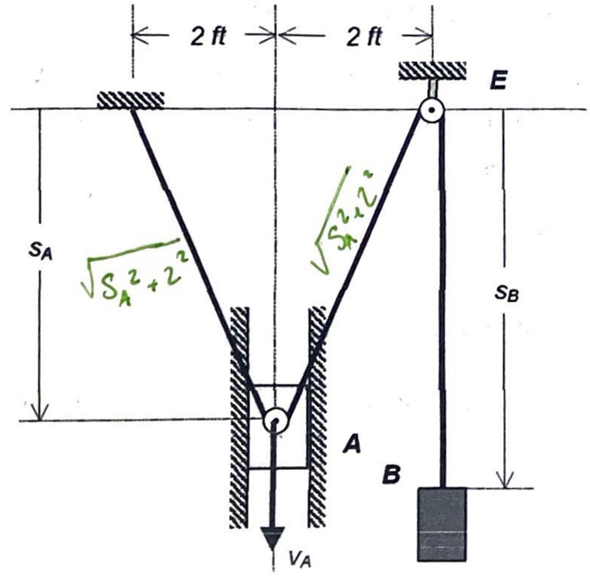
(a) $0 < v_B < 2v_A$

(b) $v_B = v_A$

(c) $v_B = 2v_A$

(d) $v_B > 2v_A$

(e) More information is needed



$$\frac{d}{dt}(L) = \frac{d}{dt}\left(\sqrt{s_A^2+2^2} + s_B\right)$$

$$0 = 2\left(\tfrac{1}{2}\right)(s_A^2+4)^{-1/2}(2s_A)(\dot{s}_A) + \dot{s}_B$$

$$= \frac{2s_A\dot{s}_A}{\sqrt{s_A^2+4}} + \dot{s}_B$$

$$\frac{2s_A}{\sqrt{s_A^2+4}} V_A = \cancel{-}V_B$$

we're just looking at magnitude of speed, disregard sign (direction)

$\frac{2s_A}{\sqrt{s_A^2+4}}$ ← this will be < 2 $\Rightarrow$ $V_B < 2V_A$

Problem 4: I am planning to add an additional office hour and would like to get a sense of when people are available. Please select the time that works best with your schedule.

(a) Monday 3:30 - 4:20
(b) Friday 3:30 - 4:20
(c) Thursday 10 – 11
(d) Thursday 3 – 4
(e) Sunday evening (remote)