TAM 212 Class 25: Rolling Motion

HomeWORK :

PL6: due W 11:59 pm

PL6: REPORT : still due tonight 11:59pm

PL7 : due M Apr 6^{th} 11:59 pm

REPORT PL7 : due M Apr 6^{th} 11:5pm

MIDTERM 2 : all computerized testing facility, TOPICS : PL 5,6,7

1^{st} CHANCE : Sat Apr 11^{th} $\longrightarrow$ W Apr 15^{th}

2^{nd} CHANCE : Sun 19^{th} Apr $\longrightarrow$ W Apr 22^{nd}

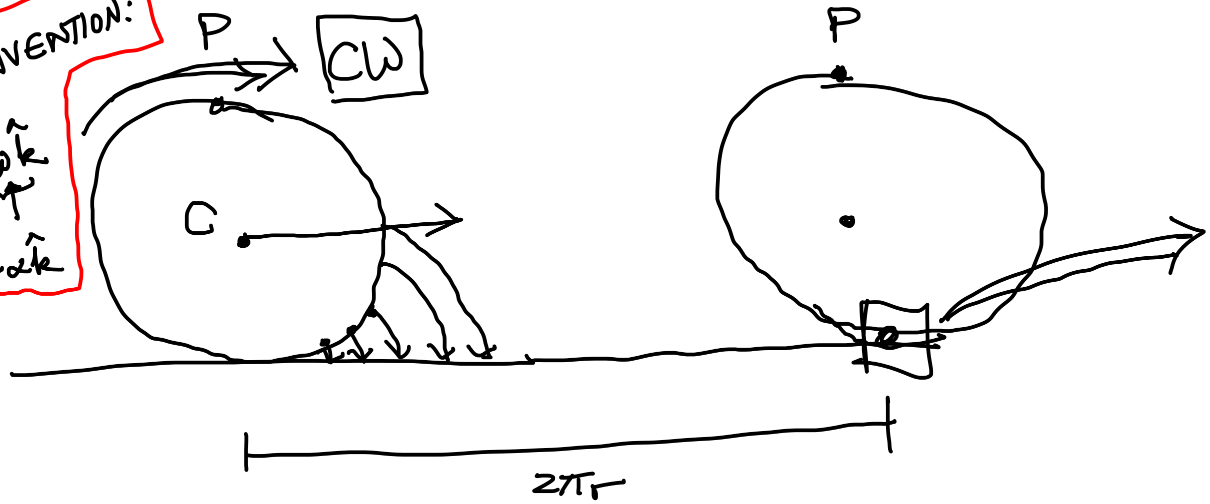
options:

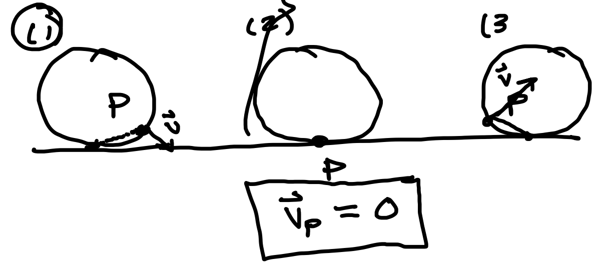
(1) take 1^{st} chance, only.

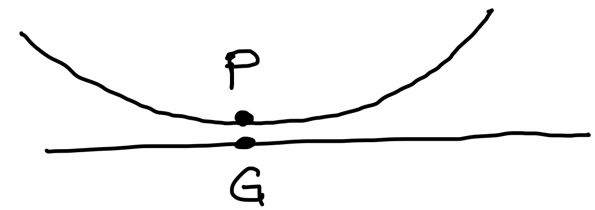
(2) take both 1^{st}, 2^{nd} $\Rightarrow$ score = max[1^{st} chance, Avg of 1,2]

Rolling w/o Slipping

By CONVENTION:
$\vec{\omega} = -\omega\hat{k}$
$\vec{\alpha} = -\alpha\hat{k}$



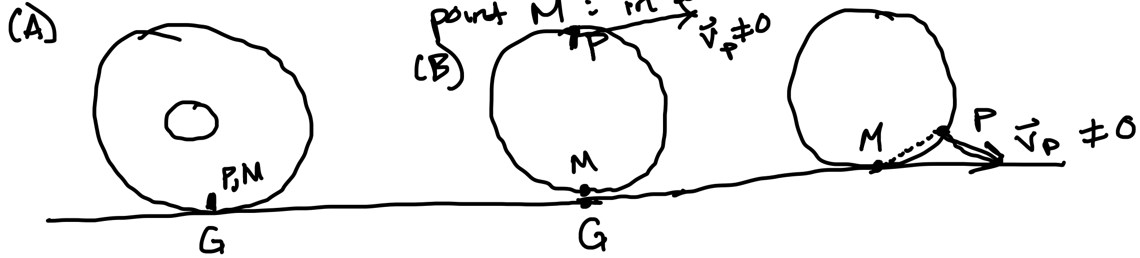


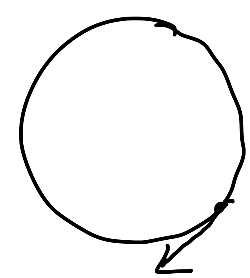


* point P is fixed to the wheel.
* point G is the point on the ground currently in contact with the wheel
* point M: is the point on the wheel that is always in contact with the gound

Rolling w/o Slipping.

point G: contact point on ground
point P: where you pump tire
point M: in contact w/ ground



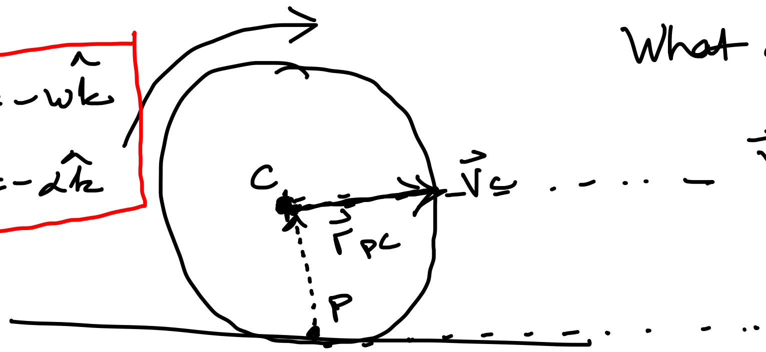


iclicker: A) TRUE B) FALSE

1) $\vec{V}_p = 0$ at (A) TRUE
2) $\vec{V}_p = 0$ always ~~TRUE~~ FALSE
3) $\vec{V}_M = 0$ always TRUE
4) $\vec{V}_G = 0$ always TRUE

$\vec{\omega} = -\omega\hat{k}$

$\vec{\alpha} = -\alpha\hat{k}$



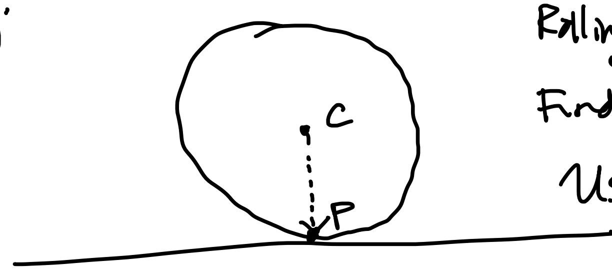
What are $\vec{v}_c$, $\vec{a}_c$? Use R.B. formulas

$$\vec{V}_C = \vec{V}_P + \vec{\omega} \times \vec{r}_{PC}$$
$$= 0 + (-\omega\hat{k}) \times (r\hat{j})$$
$$= (-\omega)(r)\,\hat{k} \times \hat{j}$$
$$= \omega r\,\hat{i} \qquad m/s$$

$$\vec{a}_c = \frac{d}{dt}(\vec{V}_C)$$
$$= \frac{d}{dt}(r\omega\,\hat{i})$$
$$= r\,\hat{i}\,\frac{d\omega}{dt} \qquad = r\alpha\,\hat{i} \qquad m/s^2$$

$$\boxed{\begin{aligned}\vec{V}_C &= r\omega\hat{i}\\ \vec{a}_c &= r\alpha\hat{i}\end{aligned}}$$

Ex):

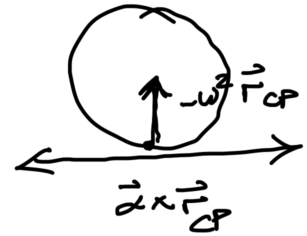


Rolling w/o slipping.

Find $\vec{a}_p$, (accel. at the instantaneous center)

Use R.B. acceleration rel.

$$\vec{a}_p = \vec{a}_c + \underbrace{\vec{\alpha} \times \vec{r}_{cp}}_{\text{tangent to } \vec{r}_{cp}} \underbrace{- \omega^2 \vec{r}_{cp}}_{\text{opposite to } \vec{r}_{cp}}$$



$$= (r\alpha\hat{i}) + (-\alpha\hat{k}) \times (-r\hat{j}) - \omega^2(-r\hat{j})$$

$$= \cancel{r\alpha\hat{i}} + \cancel{(\alpha r)(-\hat{i})} + \omega^2 r\hat{j}$$

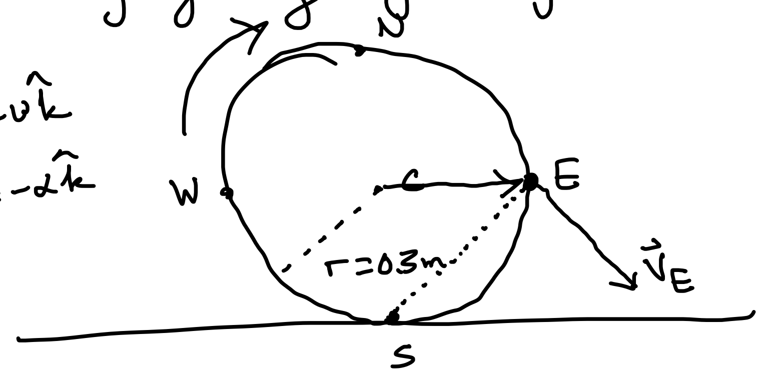
$$= \omega^2 r\,\hat{j}$$

Note: Even though $\vec{v}_p = 0$ it is not the case that $\vec{a}_p = 0$

Ex) Why getting signs right is important

$\vec{\omega} = -\omega\hat{k}$

$\vec{\alpha} = -\alpha\hat{k}$



Wheel rolls w/o slip. At a given instant $\vec{\omega} = -2\hat{k}$ rad/s, $\vec{\alpha} = 1.5\hat{k}$ rad/s^2

Find $\vec{v}_E$, $\vec{a}_E$.

good to start here

Solutions: $\vec{v}_c = r\omega\hat{i}$, $\vec{a}_c = r\alpha\hat{i}$

But be careful: $\vec{\omega} = -\omega\hat{k} = -2\hat{k}$ so

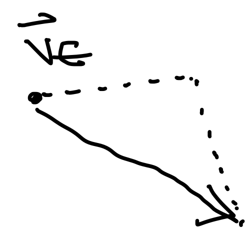
$\vec{\alpha} = -\alpha\hat{k} = 1.5\hat{k}$ so

$$\boxed{\begin{aligned} \omega &= 2 \text{ rad/s} \\ \alpha &= -1.5 \text{ rad/s}^2 \end{aligned}}$$

$\vec{v}_E = \vec{v}_c + \vec{\omega} \times \vec{r}_{CE}$

$= r\omega\hat{i} + (-\omega\hat{k} \times r\hat{i})$

$= r\omega\hat{i} + (-\omega r)(\hat{j}) = r\omega(\hat{i} - \hat{j})$



$\vec{a}_E =$