Equations of Motion: Cylindrical Components

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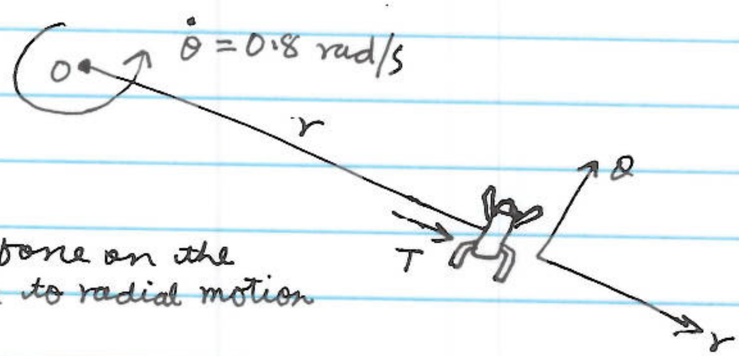
Looking at system from above



T is the force on the seat due to radial motion

$\theta = 120^\circ \longrightarrow 0.67\pi$ radians

this occurs at $t = ?$

$\dot{\theta} = 0.8 \quad \Rightarrow \quad \ddot{\theta} = 0$

by integration

$\theta = 0.8t$

so $t = \dfrac{0.67\pi}{0.8} = 2.62$ s.

now working in radians!

$r = 3\sin\theta + 5$

$= 3\sin(0.8t) + 5$ at $\theta = 2.62$ s r = ~~5.44~~ 7.59 m

$\dot{r} = 3(0.8)\cos(0.8t)$ " $\dot{r} = -1.2$ m/s

$\ddot{r} = -2.4(0.8)\sin(0.8t)$ " $\ddot{r}$ = ~~-0.07~~ -1.66 m/s^2

$\Sigma F_r = ma_r$, $a_r = \ddot{r} - r\dot{\theta}^2$

~~T = 20[-0.07 - 5.11(0.67~~

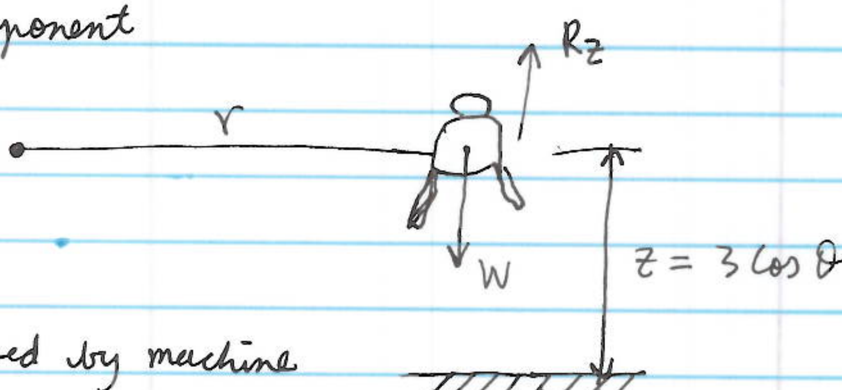
$T = 20(-1.66 - 7.59 . 0.8^2) = 130.35$ N θ - component

$$\Sigma F_\theta = m a_\theta , \quad a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}$$

let force in θ - component exerted on seat be denoted F_{th}

$$F_{th} = m(r\ddot{\theta} + 2\dot{r}\dot{\theta})$$
$$= 20\,[\,7.59(0) + 2(-1.2)(0.8)\,]$$
$$= -38.4 \text{ N}$$

z - component



R_z is caused by machine swinging seat up and down.

$$z = 3\cos\theta = 3\cos(0.8t)$$

at t = 2.62

$$z = 3\cos(0.8 . 2.62) = -1.5 \text{ m}$$
$$\dot{z} = -2.4\sin(0.8 . 2.62) = -2.07 \text{ m/s}$$
$$\ddot{z} = -1.92\cos(0.8 . 2.62) = 0.96 \text{ m/s}^2$$

$$\Sigma F_z = m a_z , \quad a_z = \ddot{z}$$

$$R_z - W = ma_z$$

$$R_z - 20(9.81) = 20(0.96)$$

$$R_z = 215.4 \text{ N}$$

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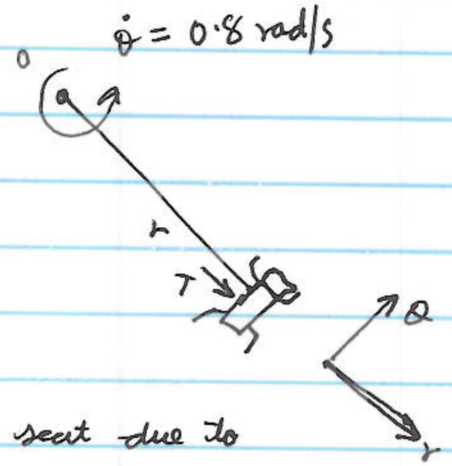
Alternate Solution Using Degrees

Looking at this system from above



T is force on seat due to radial motion

r - component

$r = 3\sin\theta + 5$ at $\theta = 120$ $r = 7.59$ m

$\dot{r} = 3\cos\theta\,\dot{\theta}$ $\dot{r} = -1.2$ m/s

$\ddot{r} = -3\sin\theta \cdot \dot{\theta}$ ~~$\ddot{r} = 1.5$ m/s²~~

$+ 3\cos\theta \cdot \ddot{\theta}$; $\ddot{r} = -2.078$ m/s²

$\Sigma F_r = m a_r$

$T = m a_r$, where $a_r = \ddot{r} - r\dot{\theta}^2$

~~$T = 20[1.5 - (-2.078)(0.8^2)]$~~

$T = 20(-2.078 - 7.59 \cdot 0.8^2)$

$T = -138.712$ N

θ - component

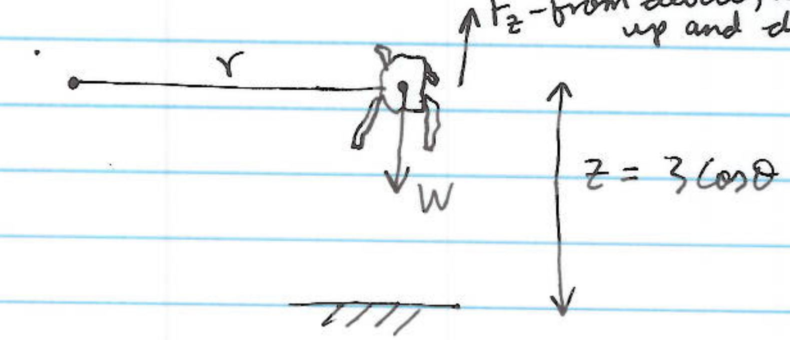
$\dot{\theta} = 0.8$

$\theta = 0.8t$

$\ddot{\theta} = 0$

students, please check my arethmetic !!

observing system from the side



$z = 3\cos\theta$

$\dot{z} = -3\sin\theta . \dot{\theta}$

$\ddot{z} = -3\cos\theta . \dot{\theta} + (-3\sin\theta) . \ddot{\theta} = -3\cos\theta . \dot{\theta}$

at $\theta = 120°$

$z = -1.5$ m

$\dot{z} = -2.078$ m/s

$\ddot{z} = 1.2$ m/s^2

$\Sigma F_z = m a_z$

$F_z - W = m a_z$

$F_z - 20(9.81) = 20(1.2)$

$F_z = 220.2$ N

θ - component

$\Sigma F_\theta = m a_\theta$

$F_\theta = m(r\ddot{\theta} + 2\dot{r}\dot{\theta})$

where F_θ is force from machine on seat in θ- component

$$F_\theta = 20\left[7.59 \cdot 0 + 2 \cdot (-1.2)(0.8)\right]$$

$$= -38.4 \text{ N}$$

[illegible]

$\pi \rightarrow 180$

0.8