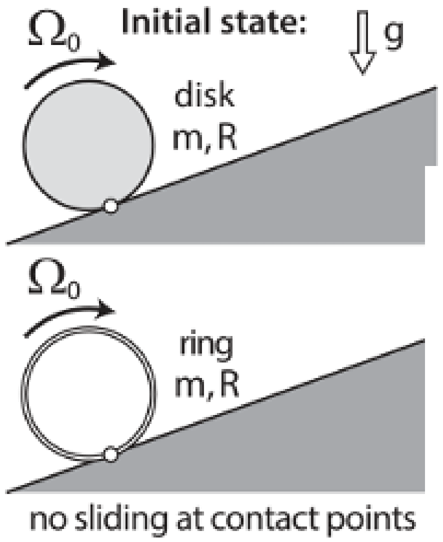


(a) "Wheel" = "disk"

Initial Energy E_{wheel}:

$$E_{\text{wheel}} = \frac{1}{2}m(r\Omega_0)^2 + \frac{1}{2}\left(\frac{1}{2}mr^2\right)\Omega_0^2$$

$$= \frac{1}{2}mr^2\Omega_0^2 + \frac{1}{4}mr^2\Omega_0^2$$

$$= \left(\frac{3}{4}\right)mr^2\Omega_0^2$$

Thus:

$$mgh_{\text{wheel}} = \frac{3}{4}mr^2\Omega_0^2$$

Thus:

$$h_{\text{wheel}} = \frac{3}{4}\frac{r^2\Omega_0^2}{g}$$

(b) **Ring**

Initial Energy E_{ring}:

$$E_{\text{ring}} = \frac{1}{2}m(r\Omega_0)^2 + \frac{1}{2}(mr^2)\Omega_0^2$$

$$= \frac{1}{2}mr^2\Omega_0^2 + \frac{1}{2}mr^2\Omega_0^2$$

$$= mr^2\Omega_0^2$$

Thus:

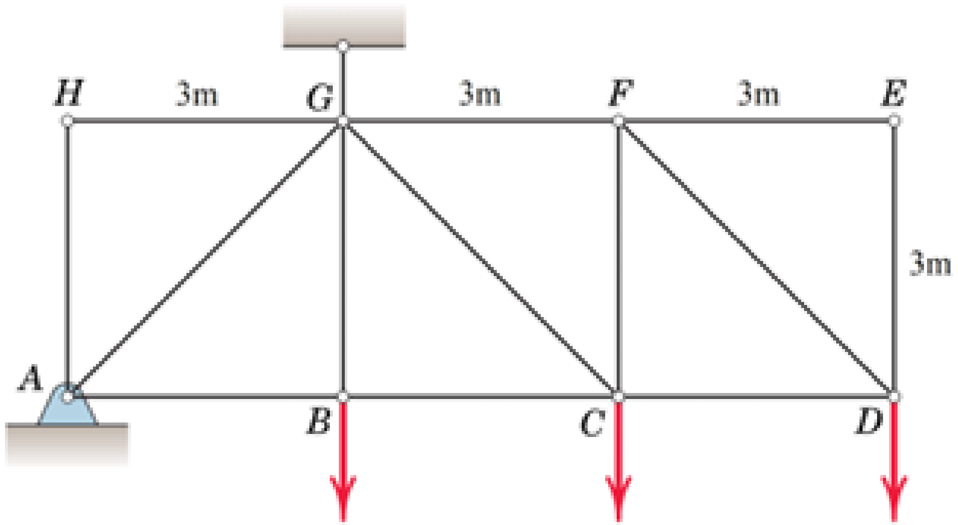
$$mgh_{\text{ring}} = mr^2\Omega_0^2$$

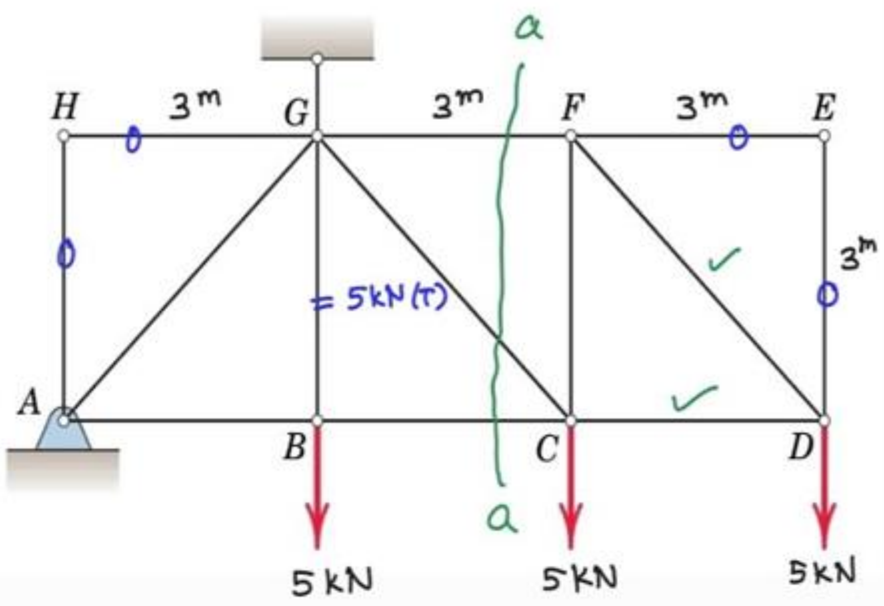
Thus:

$$h_{\text{ring}} = \frac{r^2\Omega_0^2}{g}$$

Comparing the heights achieved by the two bodies, the ring reaches a higher level by 33% times than the wheel

Answer





AH, HG, EF Answer

ED → zero-force members

(visual inspection)

*2 members, non-collinear at H.

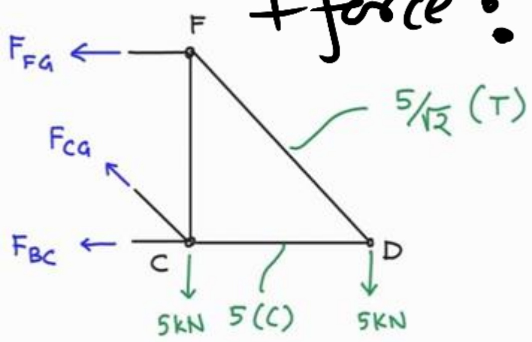
2 members -not- aligned

$F_{AB} = F_{BC}$

$F_{BG} = 5\text{ kN (T)}$

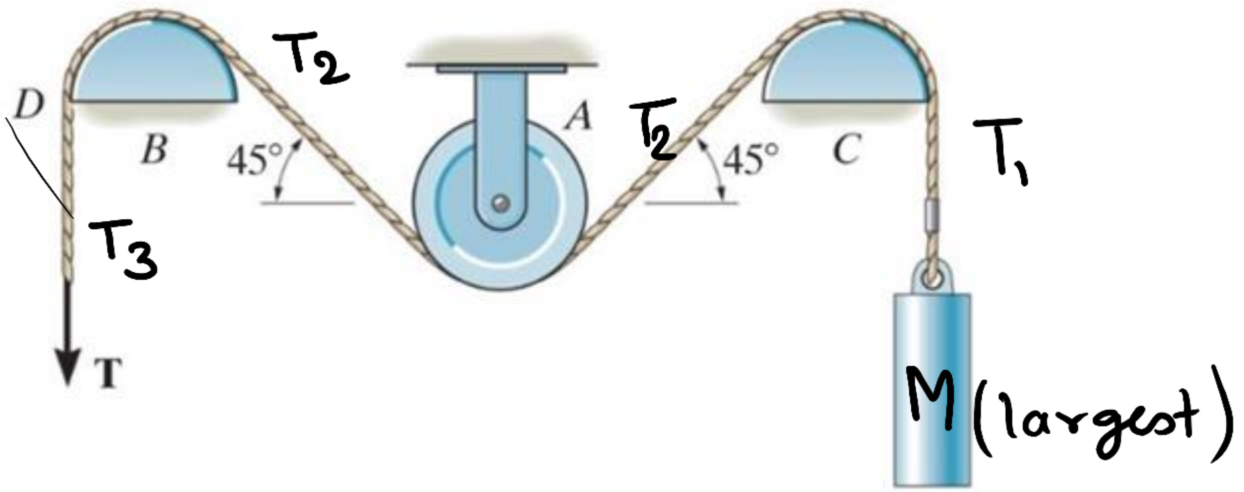
} Visual inspection

joint with 3 members + force: 2 members aligned, 3rd member aligned with a force



$+\uparrow \Sigma F_y = 0 \Rightarrow F_{CG}/\sqrt{2} - 10\text{ kN} = 0$

$\Rightarrow F_{CG} = 10\sqrt{2}\text{ kN (T)}$ Answer

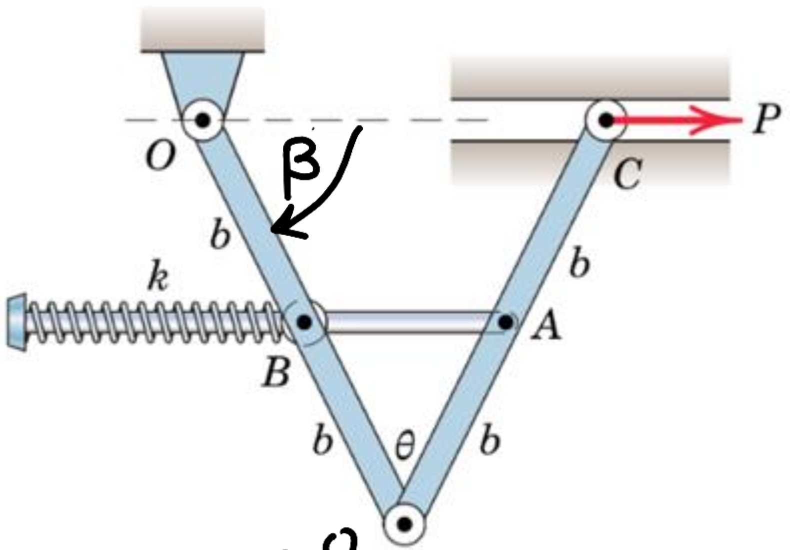


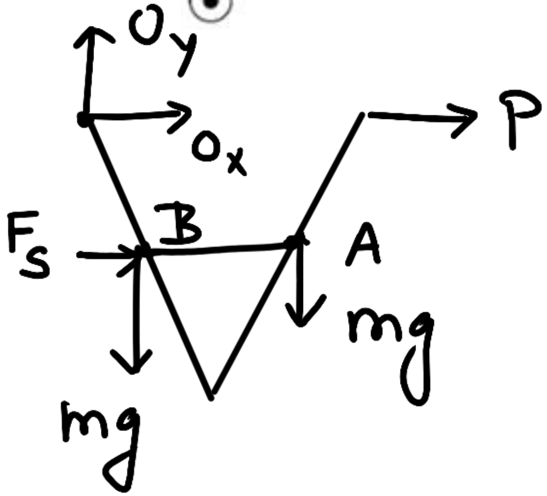
$$\frac{T_3}{T_2} = e^{\mu 3\pi/4}, \quad \frac{T_2}{T_1} = e^{\mu 3\pi/4}$$

$$T_1 = Mg, \quad T_3 = 500\,N \Rightarrow \boxed{M = 15.69\,kg}$$

$$T_3 = 600\,N \Rightarrow \boxed{M = 18.82\,kg}$$

Answer





FBD

System = {two rods of mass m + massless rod.}

F_s : spring force.

Single DoF system

O_x, O_y : Workless forces, mg, mg, F_s conservative forces.

$[V_e = \frac{1}{2}kx^2]$ $\qquad V_e = \frac{1}{2}k\left(2b\sin\frac{\theta}{2}\right)^2 = 2kb^2\sin^2\frac{\theta}{2}$

Potential function, spring

With the datum for zero gravitational potential energy taken through the support at O for convenience, the expression for V_g becomes

$[V_g = mgh]$ $\qquad V_g = 2mg\left(-b\cos\frac{\theta}{2}\right)$

The distance between O and C is $4b\sin\theta/2$, so that the virtual work done by P is

$$\delta U' = P\,\delta\left(4b\sin\frac{\theta}{2}\right) = 2Pb\cos\frac{\theta}{2}\,\delta\theta$$

The virtual-work equation now gives

$[\delta U' = \delta V_e + \delta V_g]$

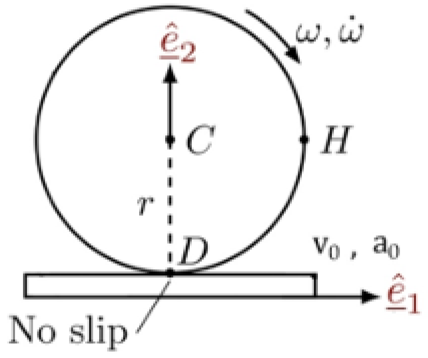
$$2Pb\cos\frac{\theta}{2}\,\delta\theta = \delta\left(2kb^2\sin^2\frac{\theta}{2}\right) + \delta\left(-2mgb\cos\frac{\theta}{2}\right)$$

$$= 2kb^2\sin\frac{\theta}{2}\cos\frac{\theta}{2}\,\delta\theta + mgb\sin\frac{\theta}{2}\,\delta\theta$$

Simplifying gives finally

$$\boxed{P = kb\sin\frac{\theta}{2} + \frac{1}{2}mg\tan\frac{\theta}{2}}$$ *Ans.*

(Both sets)



$$\underline{a}_{H|I} = (\dot{\omega} r - \omega^2 r + a_0)\,\hat{\underline{e}}_1 - \dot{\omega} r\,\hat{\underline{e}}_2$$

H is a valid point if $\dot{\omega} = 0$

$$\Rightarrow \quad \underline{a}_{H|I} = (a_0 - \omega^2 r)\,\hat{\underline{e}}_1 \quad // \quad \underline{r}_{CH}$$

and passing through C

Answer

$$\boxed{\text{Point } H \text{ is a valid point, only if } \dot{\omega} = 0}$$

The Euler's first axiom and the the modified Euler's second axiom for an RB in static equilibrium with respect to an inertial reference frame I simplify to: $\underline{F} = 0$ and $\underline{M}_A = 0$, where $\underline{F}$ is the net external force acting on the RB, and $\underline{M}_A$ represents the net moment due to all forces acting on the RB about point A. Choose the correct statement.

of this sink and this free vortex.

MCQ. Q7

We know

$\frac{d}{dt}\{\underline{H}_{A|I}\} = \underline{M}_A - \underline{r}_{CA} \times m\,\underline{a}_{A|I}$ (i) A: any arbit point

also, $\underline{H}_{A|I} = \underline{H}_{C|I} + m\underline{r}_{CA} \times \underline{v}_{CA|I}$

$\underline{H}_{C|I} = \underline{\underline{I}}^{C}\,\underline{\omega}_{m|I}$. In static equilibrium, $\underline{\omega}_{m|I} =$

$\Rightarrow \underline{H}_{C|I} = 0$. ~~Further $\underline{v}_{C|I} = 0$ in static eqn~~

$\Rightarrow \underline{H}_{A|I} = m\underline{r}_{CA} \times \underline{v}_{CA|I}$

$\therefore \frac{d}{dt}\{\underline{H}_{A|I}\}\Big|_I = \frac{d}{dt}\left(\qquad \right)\Big|_I$

$= \cancel{m\,\underline{v}_{CA|I} \times \underline{v}_{CA|I}} + m\,\underline{r}_{CA} \times \underline{a}_{CA|I}$

$= m\underline{r}_{CA} \times (\underline{a}_{C|I} - \underline{a}_{A|I}) \rightarrow$ (ii)

But in static equilibrium (RB) $\underline{a}_{C|I} = 0$.

$\Rightarrow \frac{d}{dt}\{\underline{H}_{A|I}\}\Big|_I = -m\underline{r}_{CA} \times \underline{a}_{A|I} \longrightarrow$ (ii)

Subtract (ii) from (i)

$0 = \underline{M}_A - \cancel{m\,\underline{r}_{CA} \times \underline{a}_{A|I} + m\underline{r}_{CA} \times \underline{a}_{A|I}}$

$\underline{M}_A = 0$ A: no restriction.

Answer

Acceleration of A w.r.t. frame I may or may not be zero.

Consider a rigid body which has its angular velocity always along a direction ($\hat{e}_3$) which is fixed w.r.t. to the inertial reference frame in context. The net moment due to all external forces is also known to be aligned along $\hat{e}_3$. P is a point fixed to the RB as well as to the frame I. We choose a body-fixed Cartesian coordinate system (CSYS) $Px_1(\hat{e}_1)x_2(\hat{e}_2)x_3(\hat{e}_3)$ as our working CSYS, such that P lies in the $x_1(\hat{e}_1) - x_2(\hat{e}_2)$ plane at all time instants. The modified Euler's axiom for this body is known to reduce to only one non-trivial scalar equation at all time instants: $M_{P,3} = I^P_{33}\dot{\omega}$. Based on the given information, choose the correct option.

$M_{P1} = I^P_{13}\dot{\omega} - I^P_{23}\omega^2$ (P is a valid point)

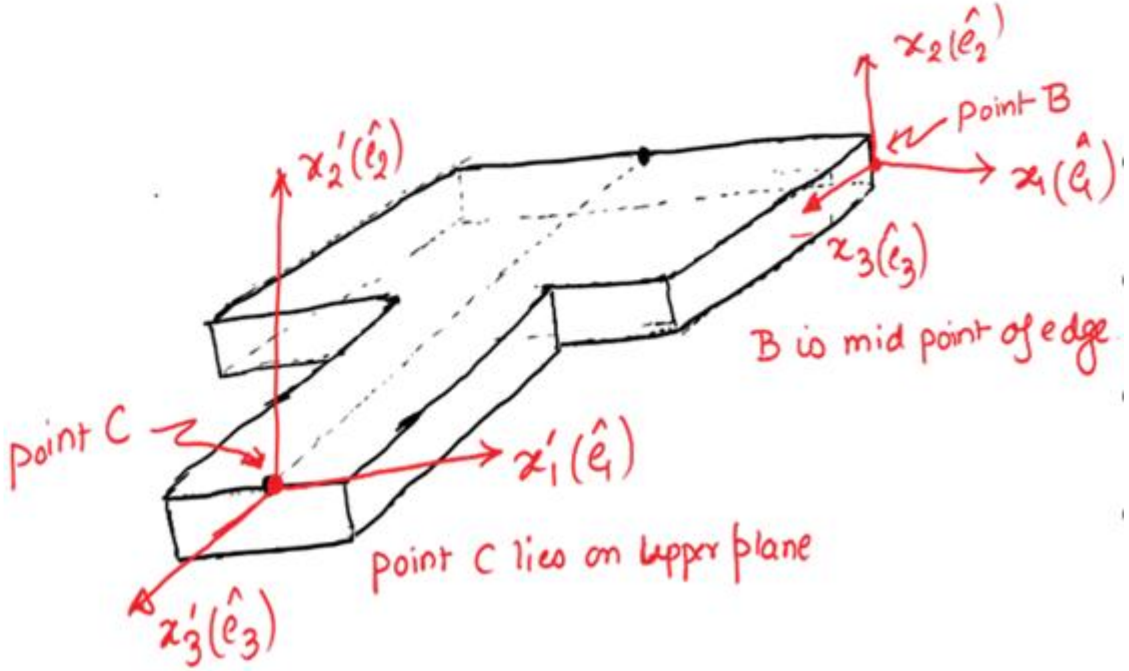
$M_{P2} = I^P_{23}\dot{\omega} + I^P_{13}\omega^2$

$M_{P3} = I^P_{33}\dot{\omega}$. 1st 2 equ^ns become trivial when

$I^P_{13} = 0$, $I^P_{23} = 0$,

$x_3(\hat{e}_3)$ principal axes of inertial at P.

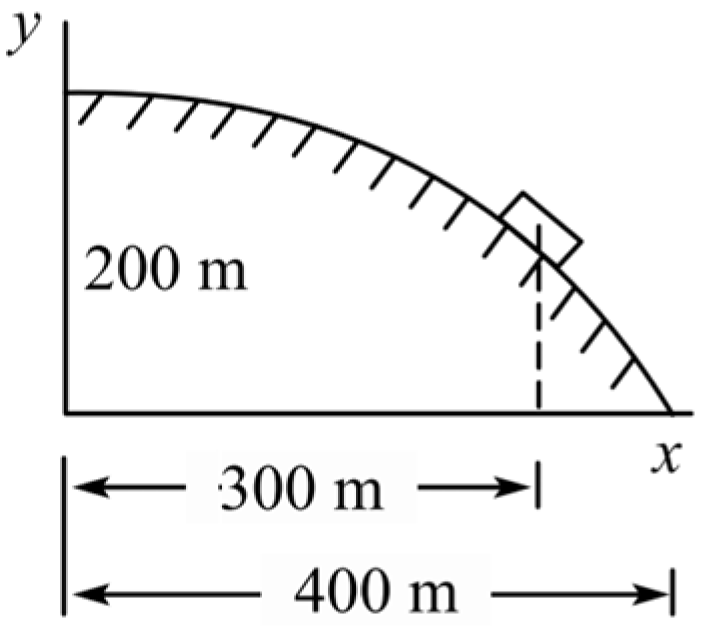
$\boxed{\text{The axis } x_3(\hat{e}_3) \text{ must be a principal axis of the inertia tensor of the body at P.}}$ Answer



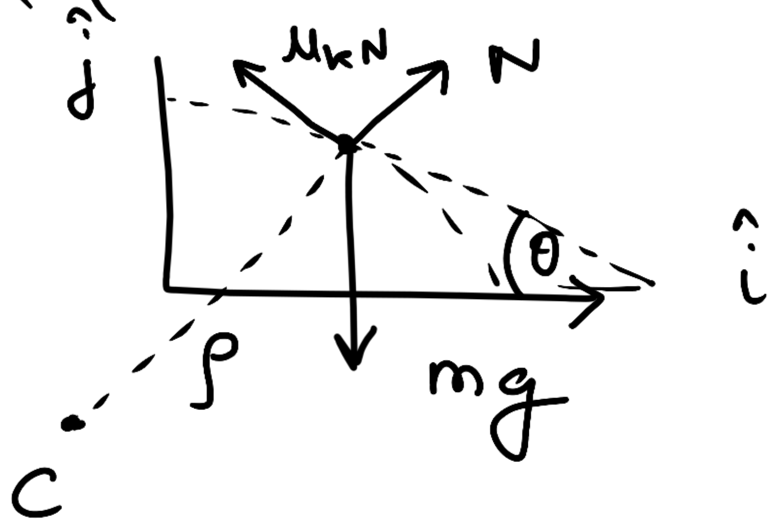
only $x_1(\hat{e}_1) - x_3(\hat{e}_3)$ plane is a symm. plane at B.

only $x_2(\hat{e}_2)$ is a p-axis — based on visual inspection

$\boxed{\text{None of these is correct.}}$ Answer



FBD of block (point mass)



$$mg\sin\theta - \mu_k N = m\ddot{s}$$

$$mg\cos\theta - N = \frac{m\dot{s}^2}{\rho} \qquad \rho : \text{given } 1597.5\,\text{m}.$$

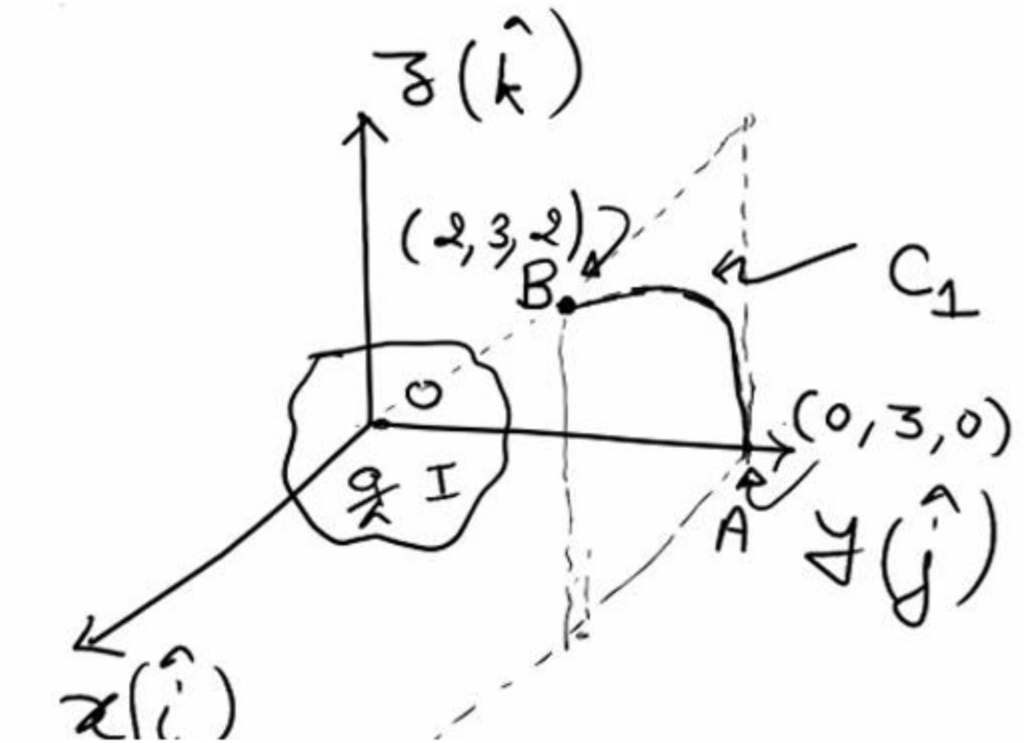
Eliminate N $\Rightarrow$ $\ddot{s} = g\sin\theta - \mu_k \cos\theta + \mu_k \dot{s}^2/\rho$

$y = 200\cos(\pi x/800) \Rightarrow dy/dx = -\tan\theta = \frac{\pi}{4}\sin\frac{3\pi}{8} \Rightarrow \sin\theta = 0.58,\ \cos\theta = 0.81$

If $v = 100\,\text{ms}^{-1} \Rightarrow \ddot{s} = 5.45\ \text{ms}^{-2}$

If $v = 150\,\text{ms}^{-1} \Rightarrow \ddot{s} = 7.01\ \text{ms}^{-2}$.

A force depends only on the Cartesian coordinates x, y and z: $\underline{F} = (-2xy + z)\hat{i} + (-x^2 + xz - z)\hat{j} + (xy - y)\hat{k}$.



Check if $\underline{\nabla} \times \underline{F} = 0$

For the given $\underline{F}$,

$\underline{\nabla} \times \underline{F} \neq 0$

$\Rightarrow \underline{F}$ is not conservative.

$\Rightarrow V$ does not exist