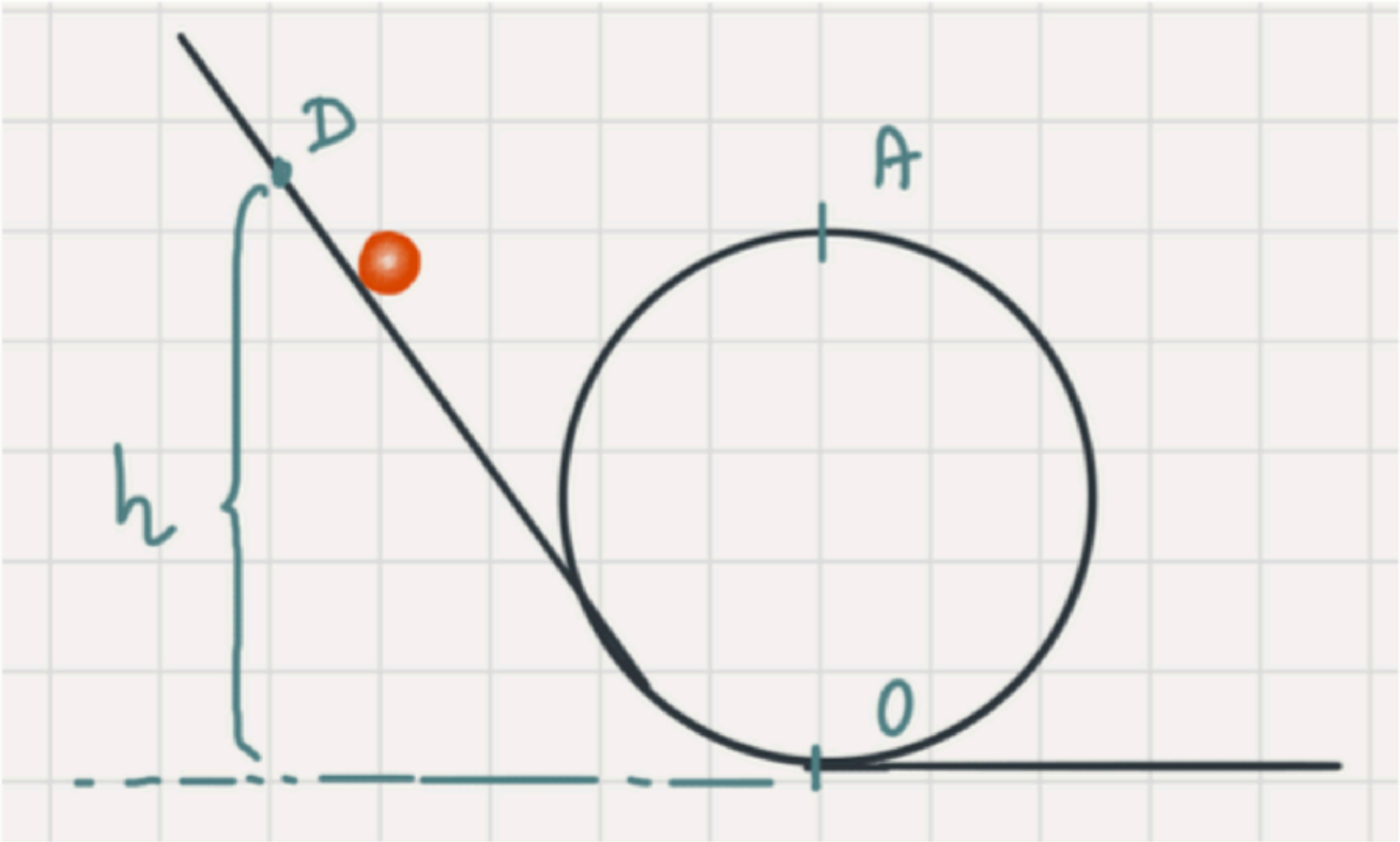

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A) What is the minimum starting height in terms of R so that the ball completes the loop without falling off the track?

PHYS-101 WEEK 8

EPFL

Physique générale : mécanique (classe inversée en anglais)

Prof. Emma Tolley, 27 October 2025

MID-TERM COURSE FEEDBACK

Nb Registered	138
Nb Answered	60

Remarks

[35 remarque(s)]

Main criticism/suggestions:

- Too many quizzes/quizzes aren't helpful
- More exercises and/or harder exercises in the Monday lecture
- Friday recitation is too fast
- Exercise solutions should be posted earlier
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- Monday: fewer quizzes, more detailed explanation, harder exercises / will connect exercise to the problem sets more explicitly
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Course adjustments

- Monday: fewer quizzes, more detailed explanation, harder exercises / will connect exercise to the problem sets more explicitly
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- Recommend starting problem sets in the week, attending the evening exercise sessions / asking questions in the forum, before coming to the Friday session

REMINDER

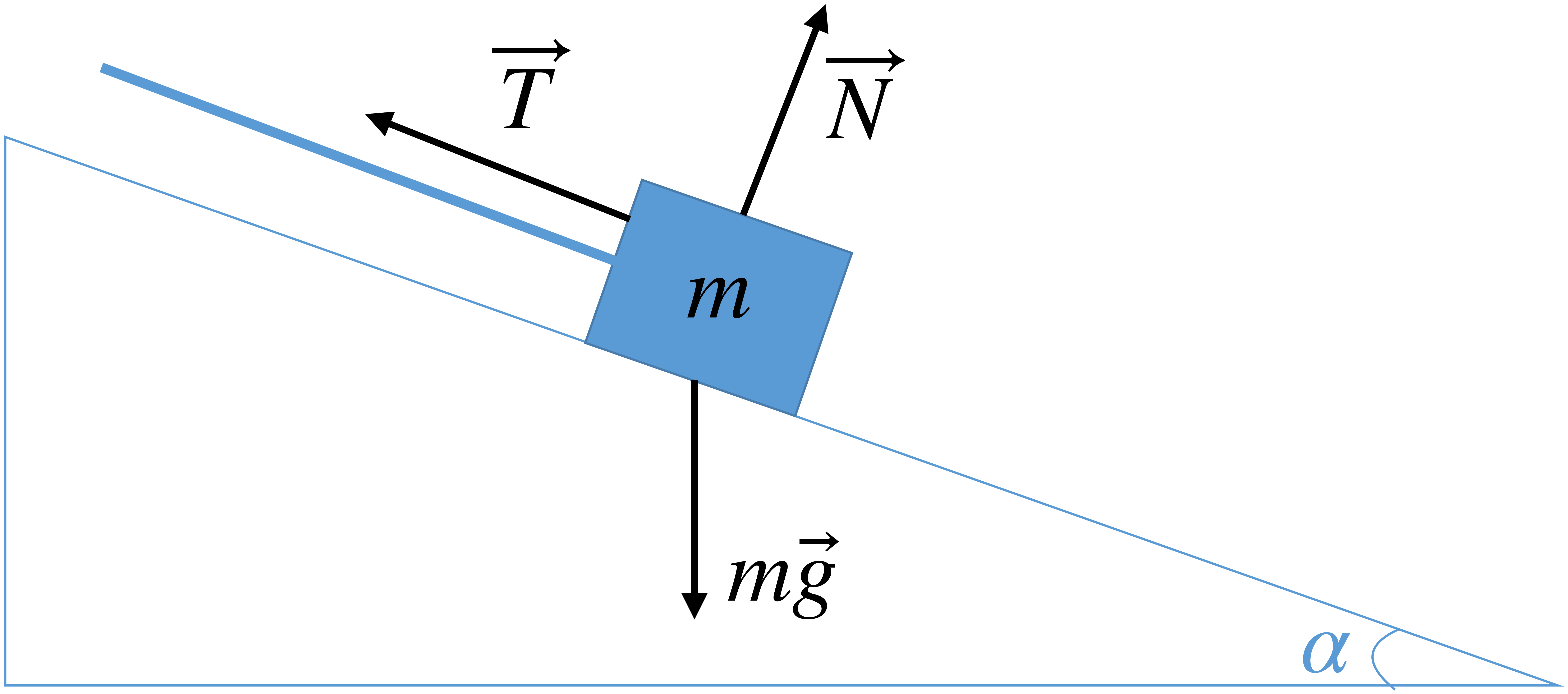
Additional evening exercise sessions:

- **Tuesdays** from 17h30-19h in CE 1 101
- **Thursdays** from 18h15-19h45 in MA A1 10

If you have any questions about the exercises, recorded lectures course concepts, etc– ask on the Forum!

On the forum, we now have a pinned weekly poll to decide topics in the Recitation, be sure to vote or comment if you want to see anything specific

ON FRICTION



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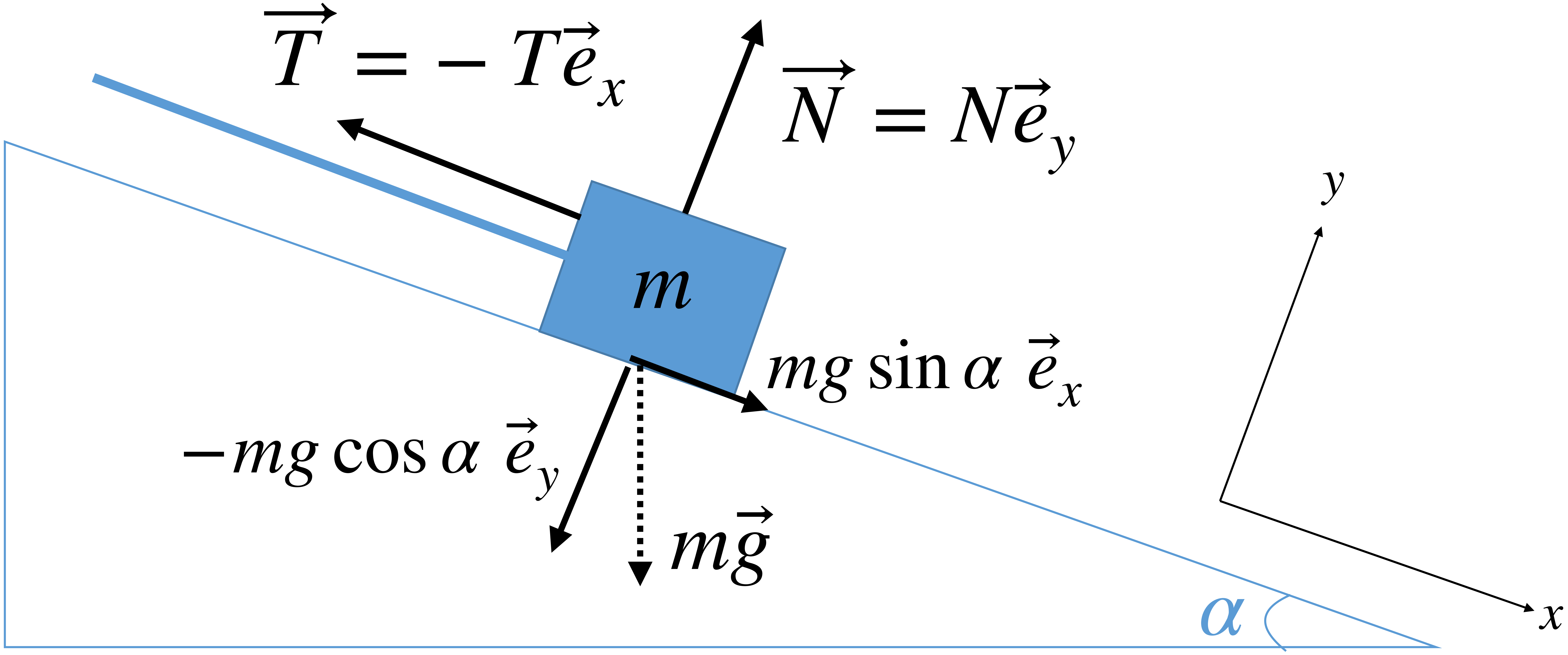
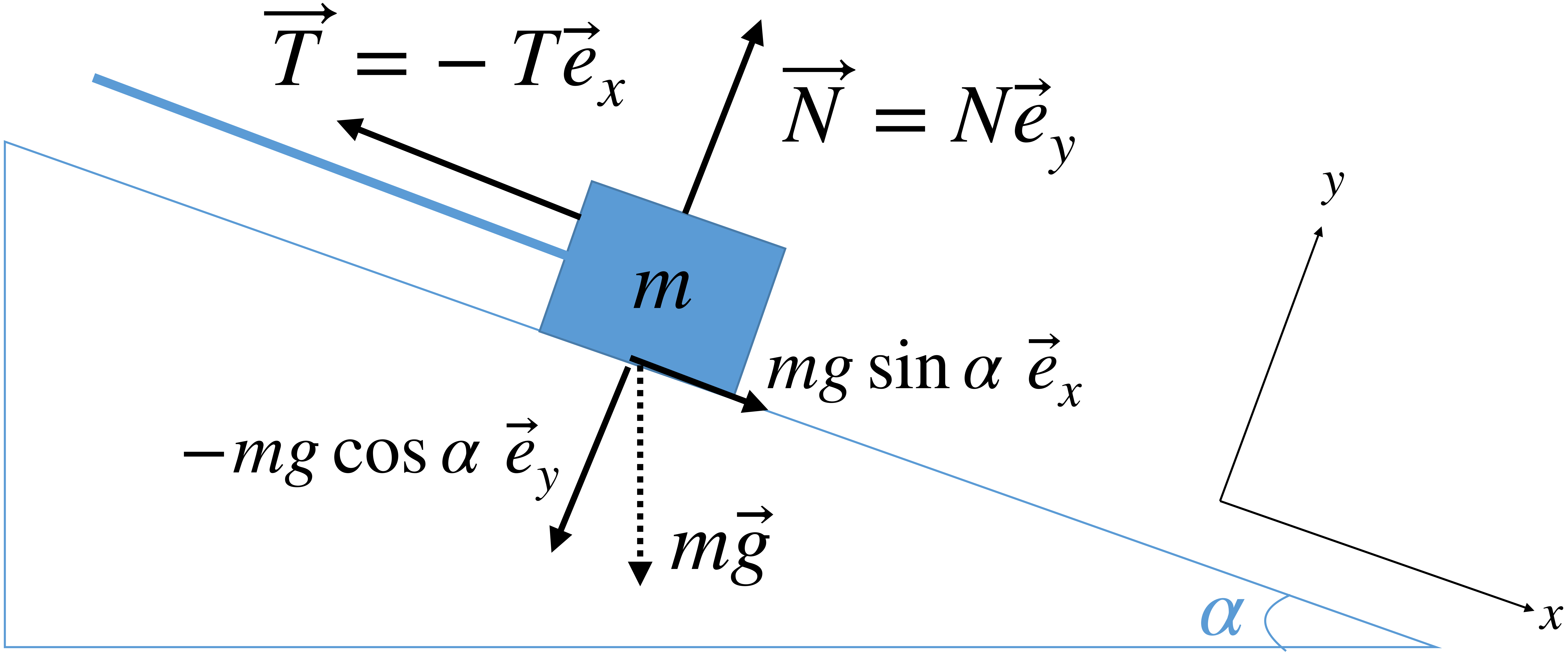


$\vec{T} = -T\vec{e}_x$
$\vec{N} = N\vec{e}_y$
y
m
$mg \sin\alpha\ \vec{e}_x$
$-mg\cos\alpha\ \vec{e}_y$
$m\vec{g}$
α
x

ON FRICTION

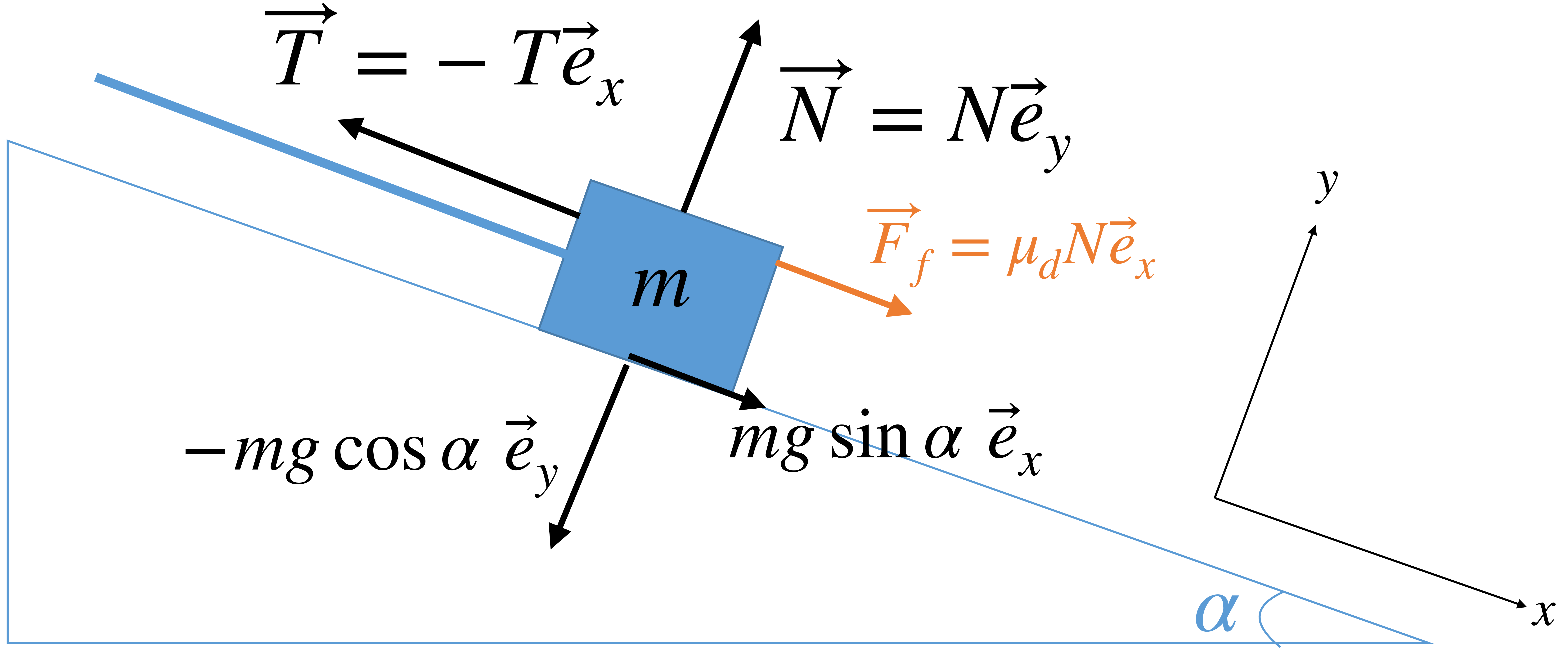


$$m\ddot{y} = 0 = N - mg\cos\alpha$$

$$m\ddot{x} = mg\sin\alpha - T$$

ON FRICTION

Block is moving uphill, $\dot{x} < 0$

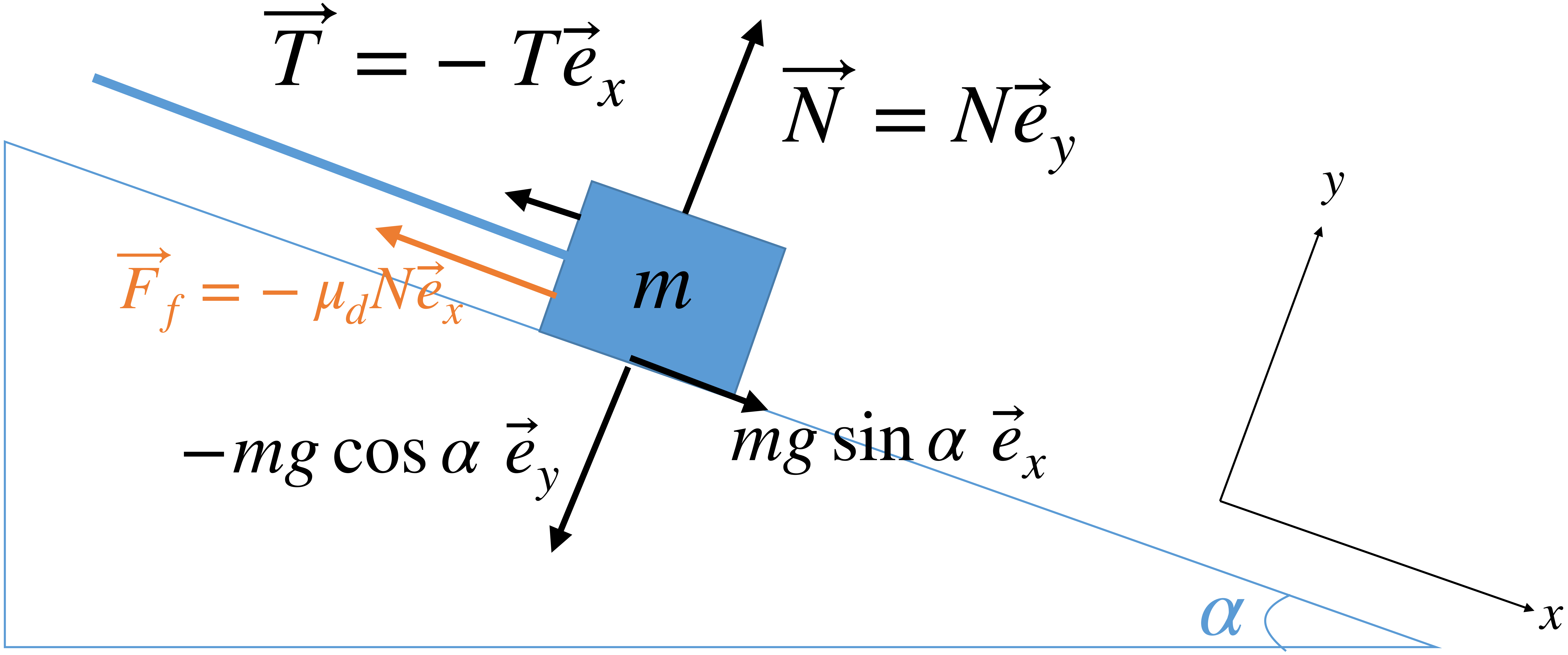


$$m\ddot{y} = 0 = N - mg\cos\alpha$$

$$m\ddot{x} = mg\sin\alpha - T + \mu_d N$$

ON FRICTION

Block is moving downhill, $\dot{x} > 0$



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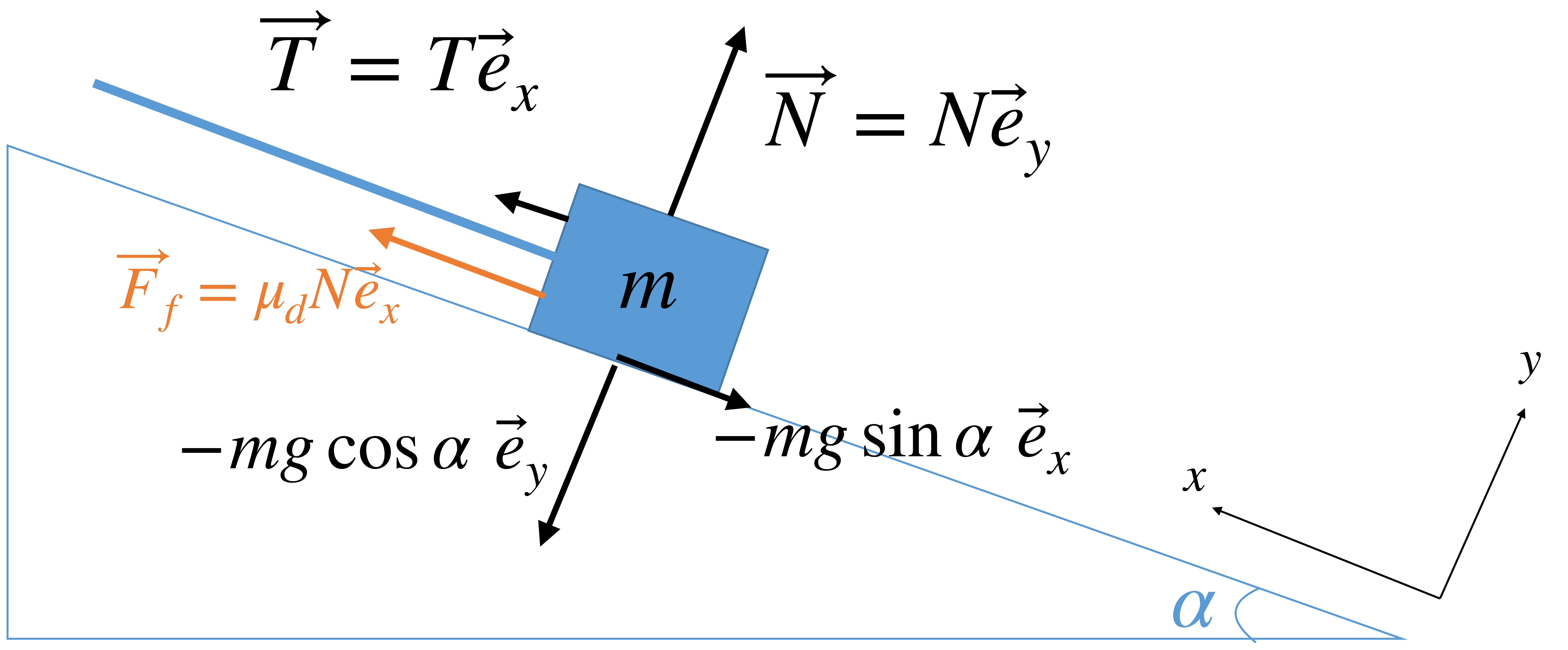
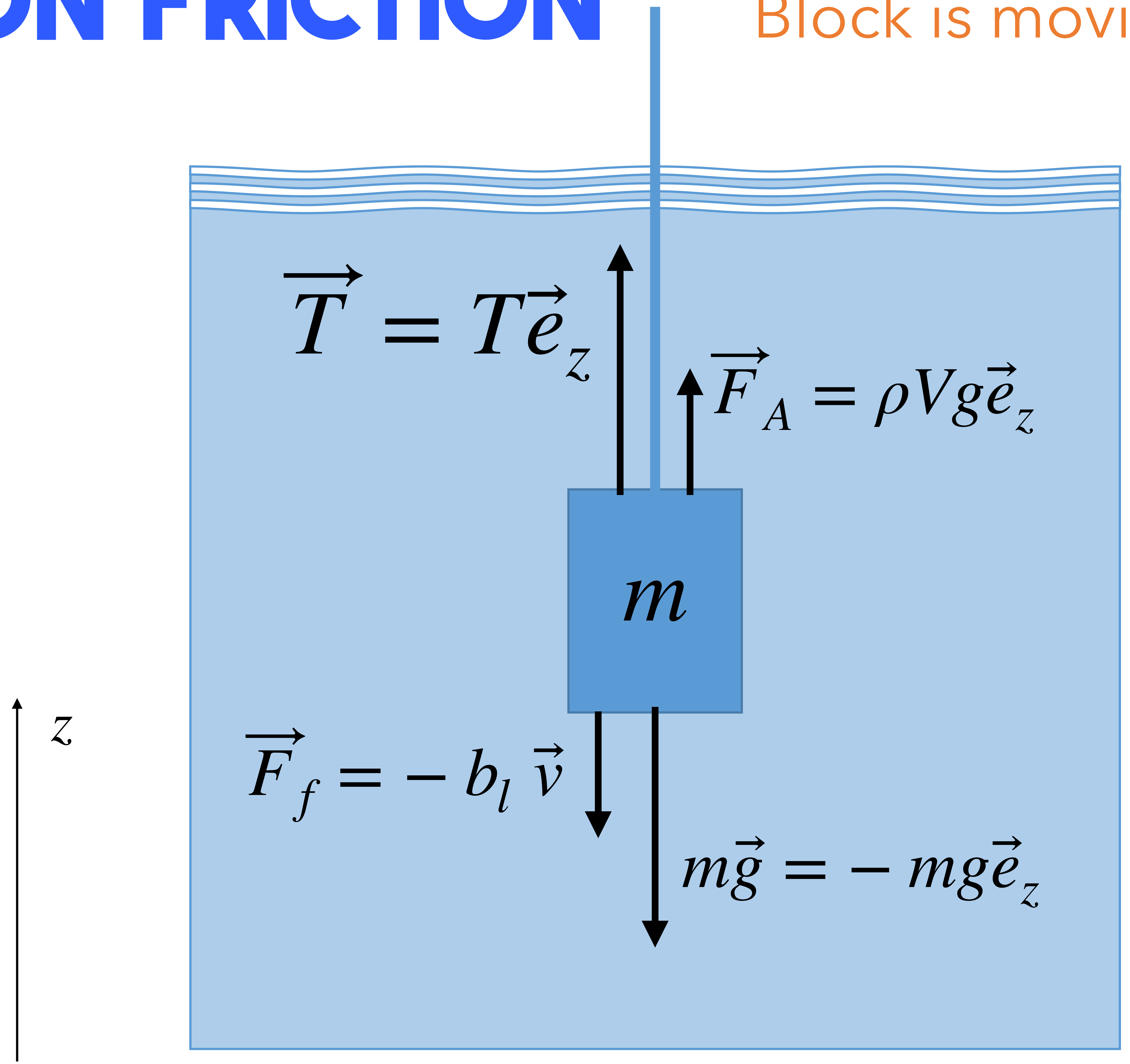


$$m\ddot{y} = 0 = N - mg\cos\alpha$$

$$m\ddot{x} = -\,mg\sin\alpha + T + \mu_d N$$

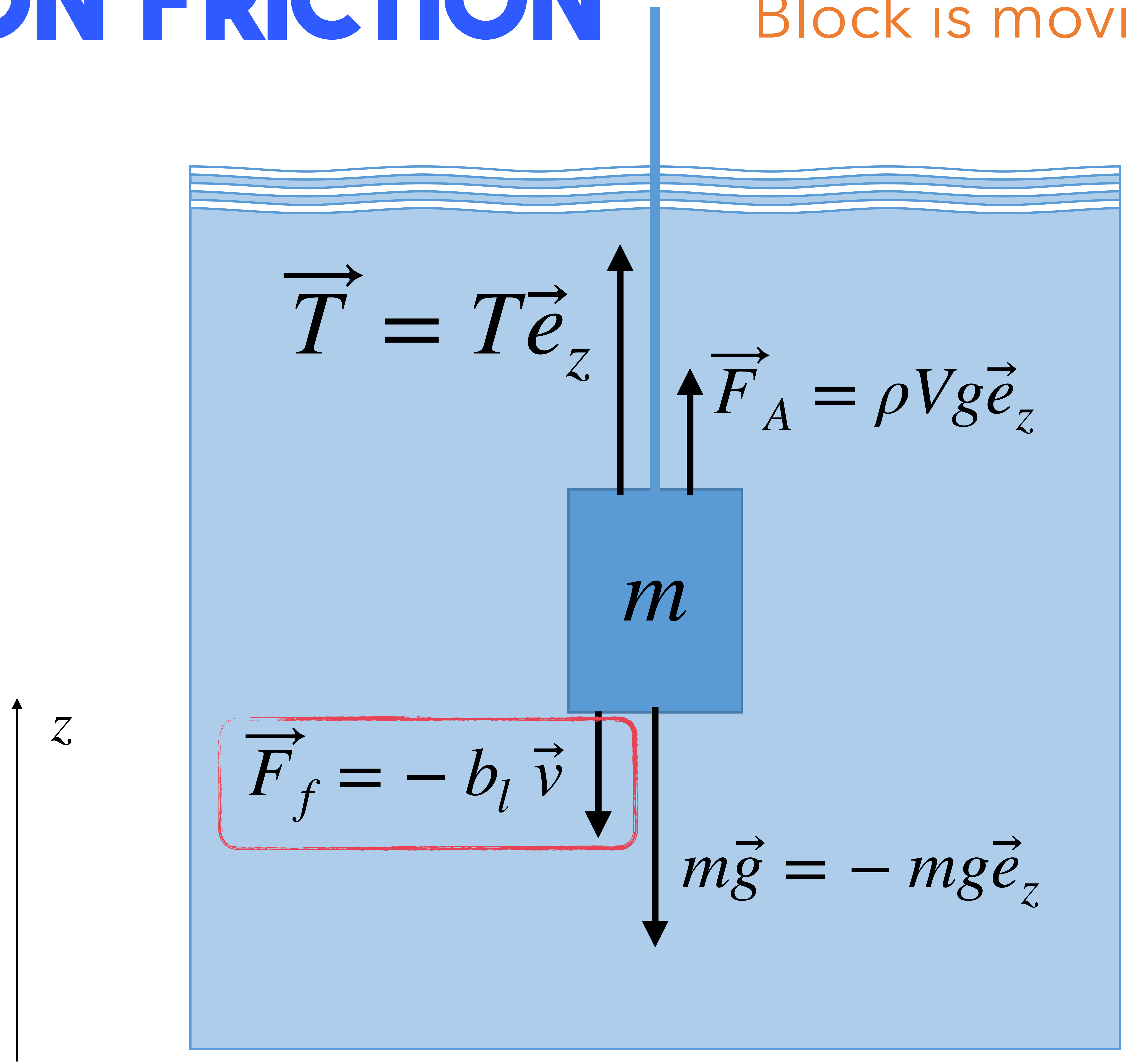
ON FRICTION

Block is moving upwards, $\dot{z} > 0$



ON FRICTION

Block is moving upwards



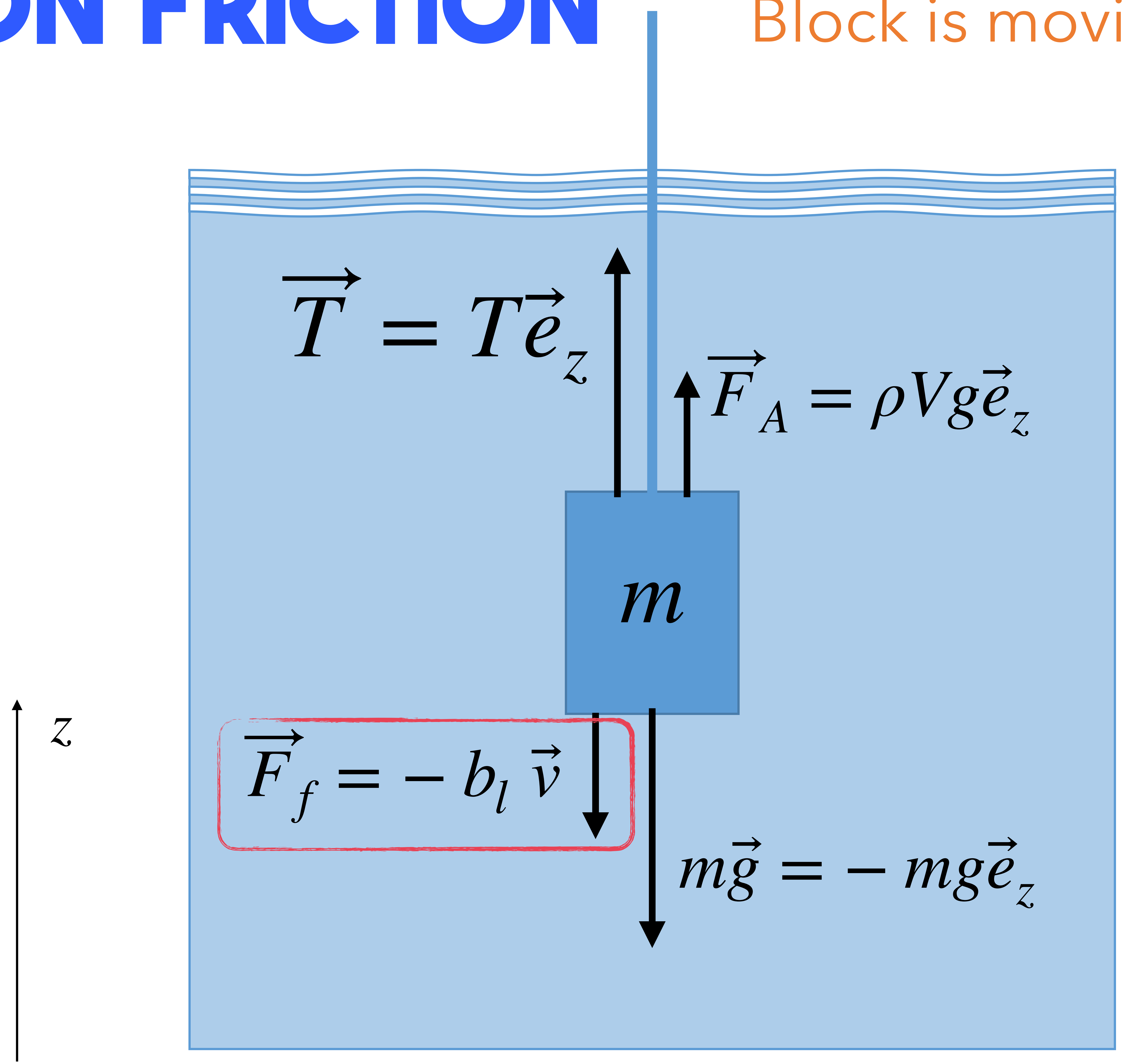
$$\vec{F}_f = -b_l\,\vec{v}$$

$$\vec{F}_f = -b_l\,|\vec{v}|\,\vec{e}_z = -b_l\,|\dot{z}|\,\vec{e}_z$$

Technically correct but not recommended

ON FRICTION

Block is moving upwards $\dot{z} > 0$



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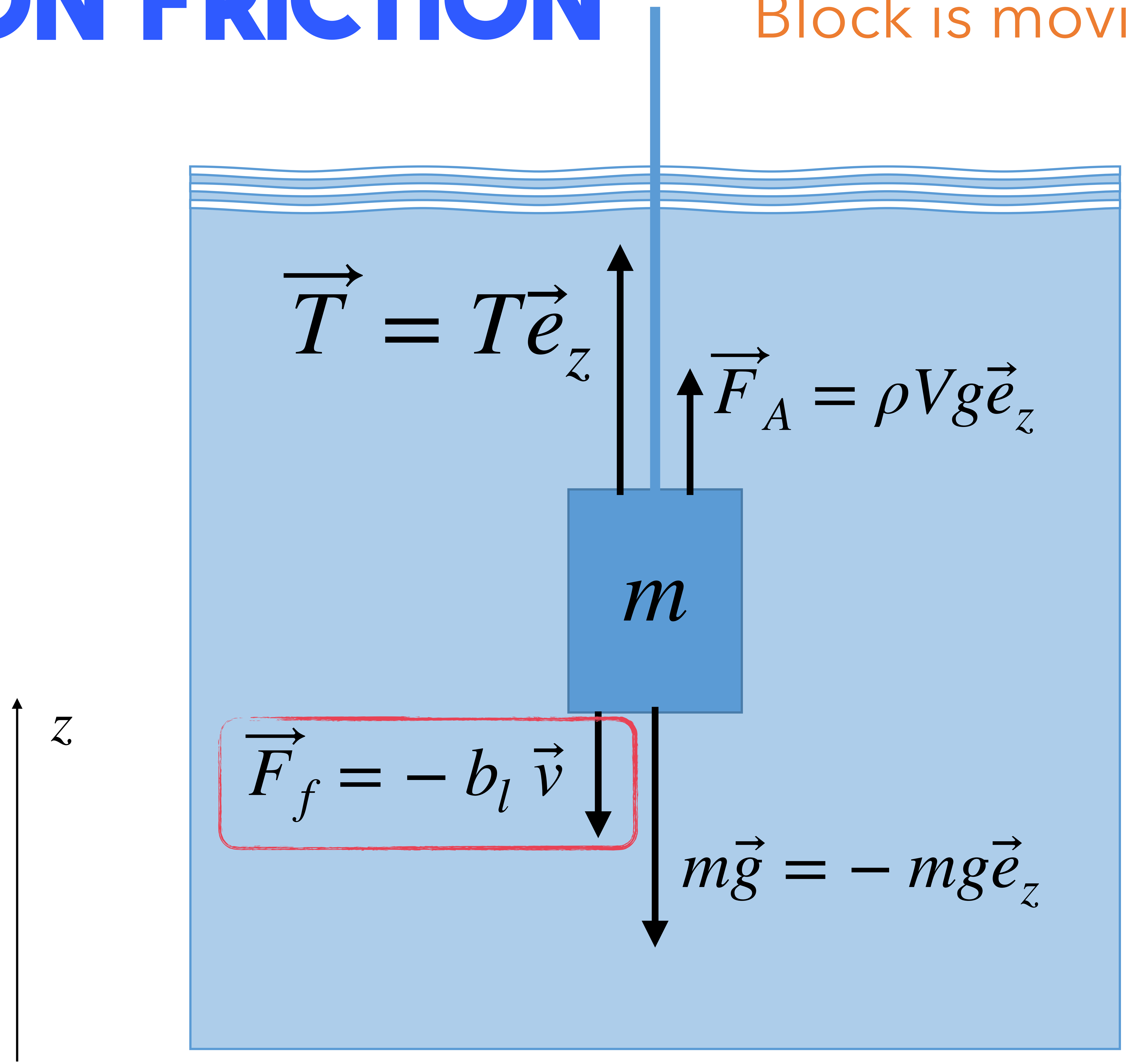
Technically correct but not recommended

$$m\ddot{z} = T + \rho V g - mg - b_l|\dot{z}|$$

Nonlinear differential equation!

ON FRICTION

Block is moving upwards $\dot{z} > 0$



$$\vec{F}_f = -b_l \vec{v} \qquad \vec{v} = \dot{z}\vec{e}_z$$

$$\vec{F}_f = -b_l \dot{z} \vec{e}_z$$

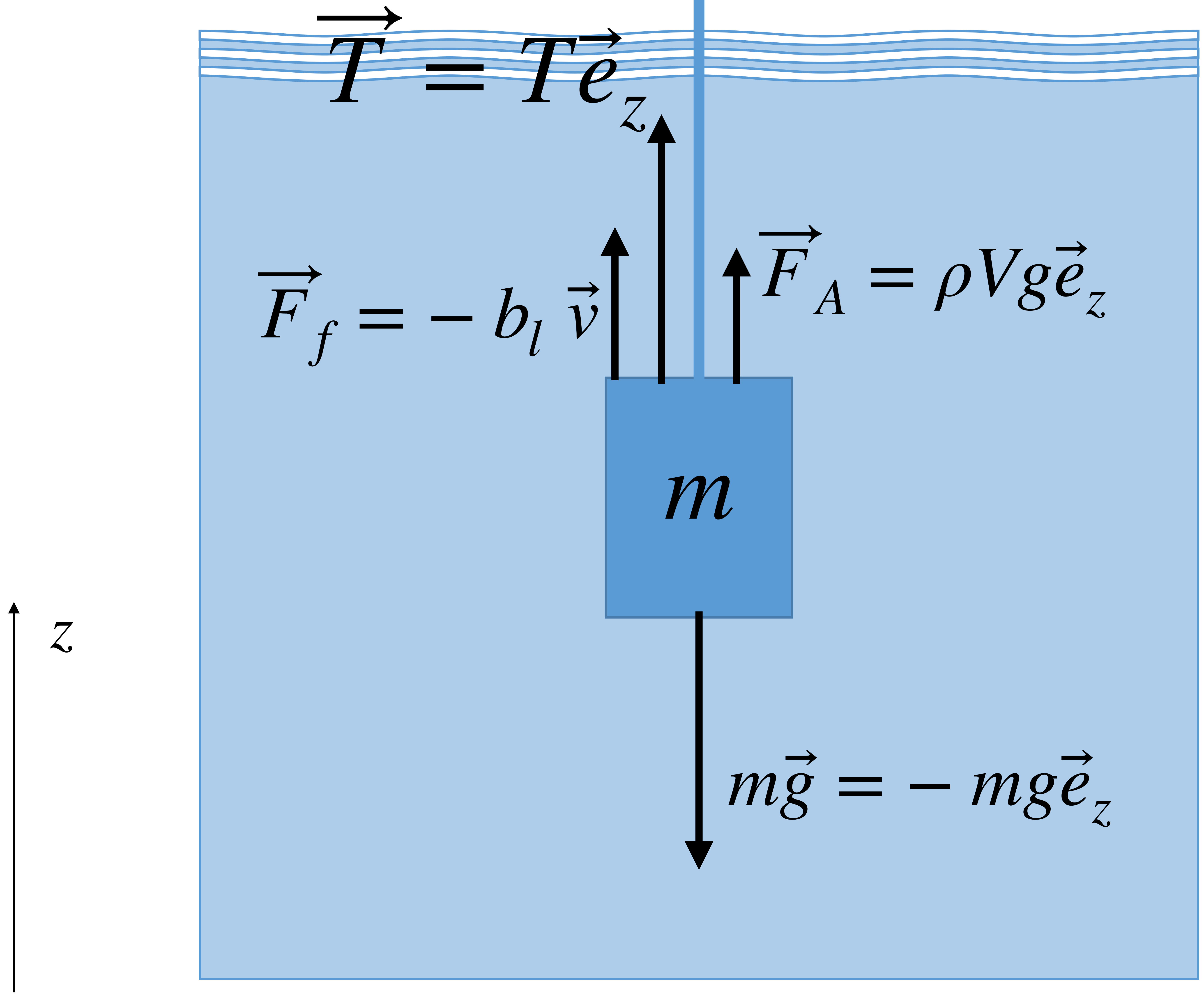
Do this instead

$$m\ddot{z} = T + \rho V g - mg - b_l \dot{z}$$

Linear differential equation!

ON FRICTION

Block is moving downwards, $\dot{z} < 0$

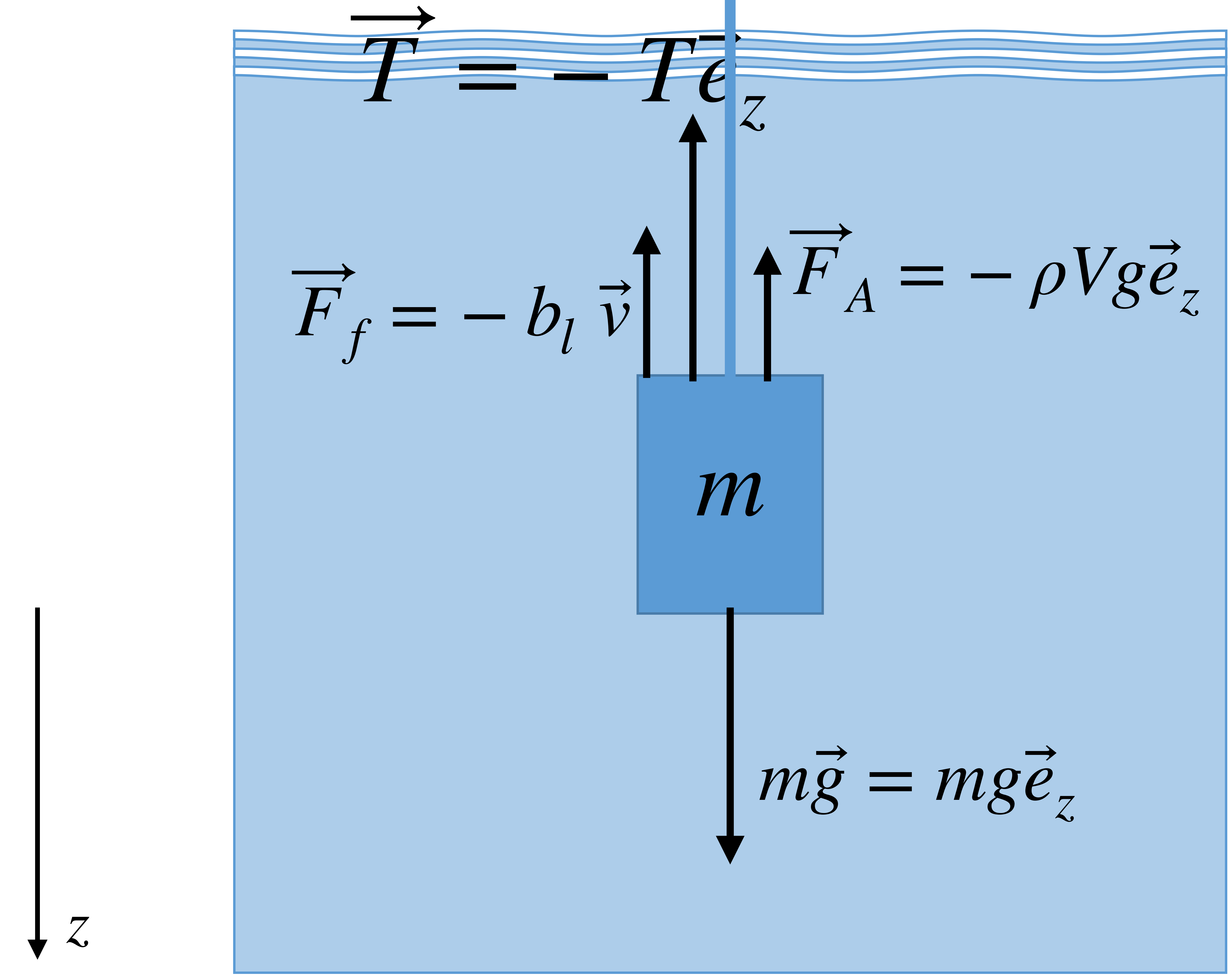


$$\overrightarrow{F}_f = -b_l\,\dot{z}\,\vec{e}_z$$

$$m\ddot{z} = T + \rho V g - mg - b_l\dot{z}$$

ON FRICTION

Block is moving downwards, $\dot{z} > 0$



$$\vec{F}_f = -b_l\,\dot{z}\,\vec{e}_z$$

$$m\ddot{z} = -T - \rho V g + mg - b_l\dot{z}$$

WEEK 8: WORK & ENERGY

Work done by a force: $W_{AB}^{\vec{F}} = \int_A^B \vec{F} \cdot d\vec{r}$

Only the component of the force **tangent to the motion** does work

WEEK 8: WORK & ENERGY

Work done by a force: $W_{AB}^{\vec{F}} = \int_A^B \vec{F} \cdot d\vec{r}$ Only the component of the force **tangent to the motion** does work

Kinetic energy: $E_c = \frac{1}{2} m v^2$

Work changes the kinetic energy: $W_{AB}^{\vec{F}_{\text{tot}}} = E_{c,B} - E_{c,A}$

WEEK 8: WORK & ENERGY

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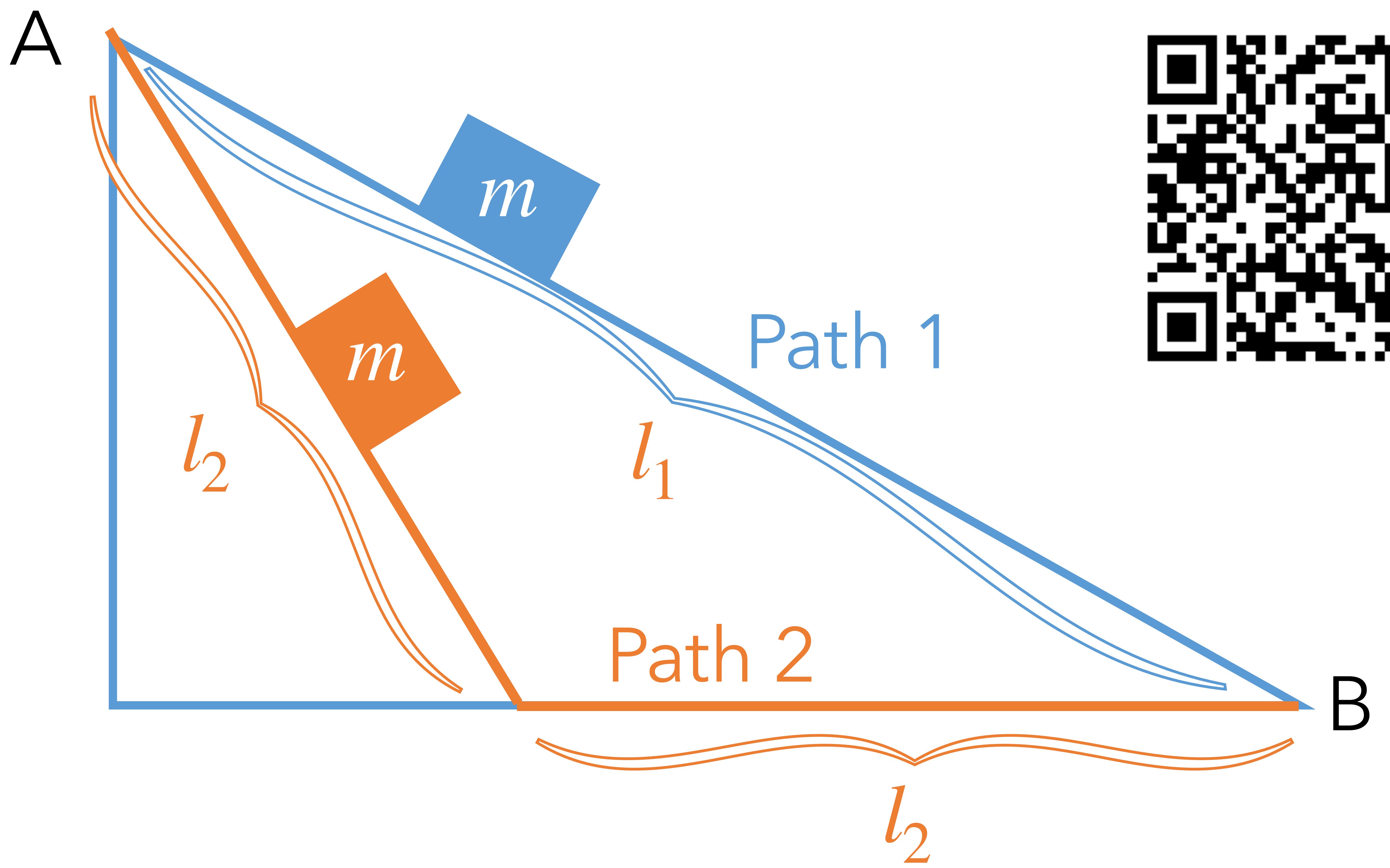
Kinetic energy: $E_c = \frac{1}{2}mv^2$ Work changes the kinetic energy: $W_{AB}^{\vec{F}_{\text{tot}}} = E_{c,B} - E_{c,A}$

A force is **conservative** if the work doesn't depend on the path between points A and B. Conservative forces have **potential energy**:

$$W_{AB}^{\vec{F}} = E_{p,A}^{\vec{F}} - E_{p,B}^{\vec{F}} \qquad E_p^{m\vec{g}} = mgz \qquad E_p^{\vec{F}_k} = \frac{1}{2}kx^2$$

If all working forces are conservative, mechanical energy is constant: $E_m = E_p + E_c$

QUIZ: TWO TRAJECTORIES

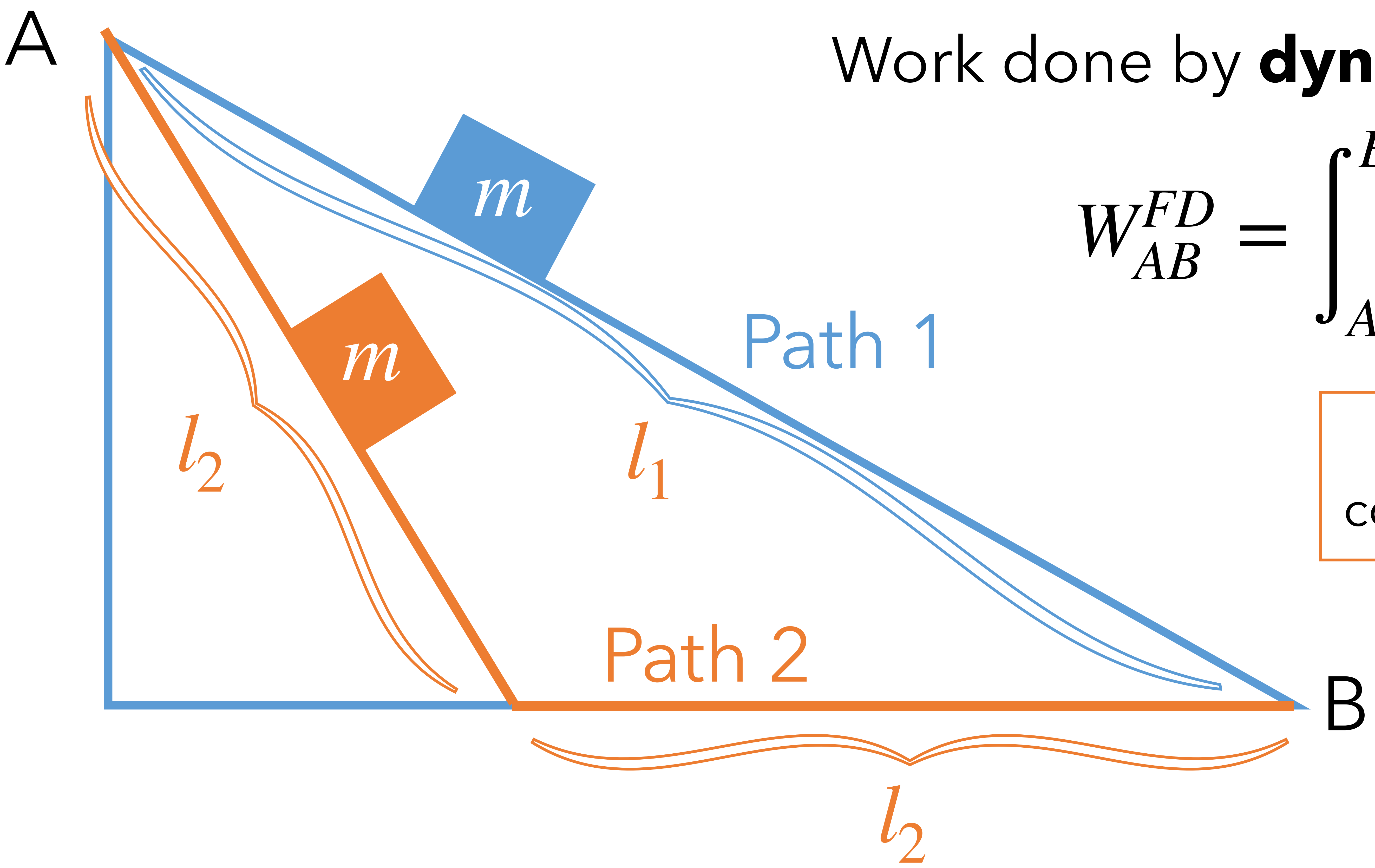


Two identical blocks slide along two different paths from point A to point B and are subject to the same coefficient of friction μ_d. Which block will arrive at point B with greater speed?

- The block on path 1 — 0%
- The block on path 2 — 0%
- Both blocks will arrive with the same speed — 0%
- Impossible without knowing the specific angles and lengths traveled — 0%

No votes

WORK & FRICTION



Work done by **dynamic dry friction** $\vec{F}_D$

$$W_{AB}^{FD} = \int_A^B \vec{F}_D \cdot \vec{dr} = -F_D \int_A^B dr = -F_D\, l$$

Can only take FD out of the integral if it is constant along the path (slope not changing)

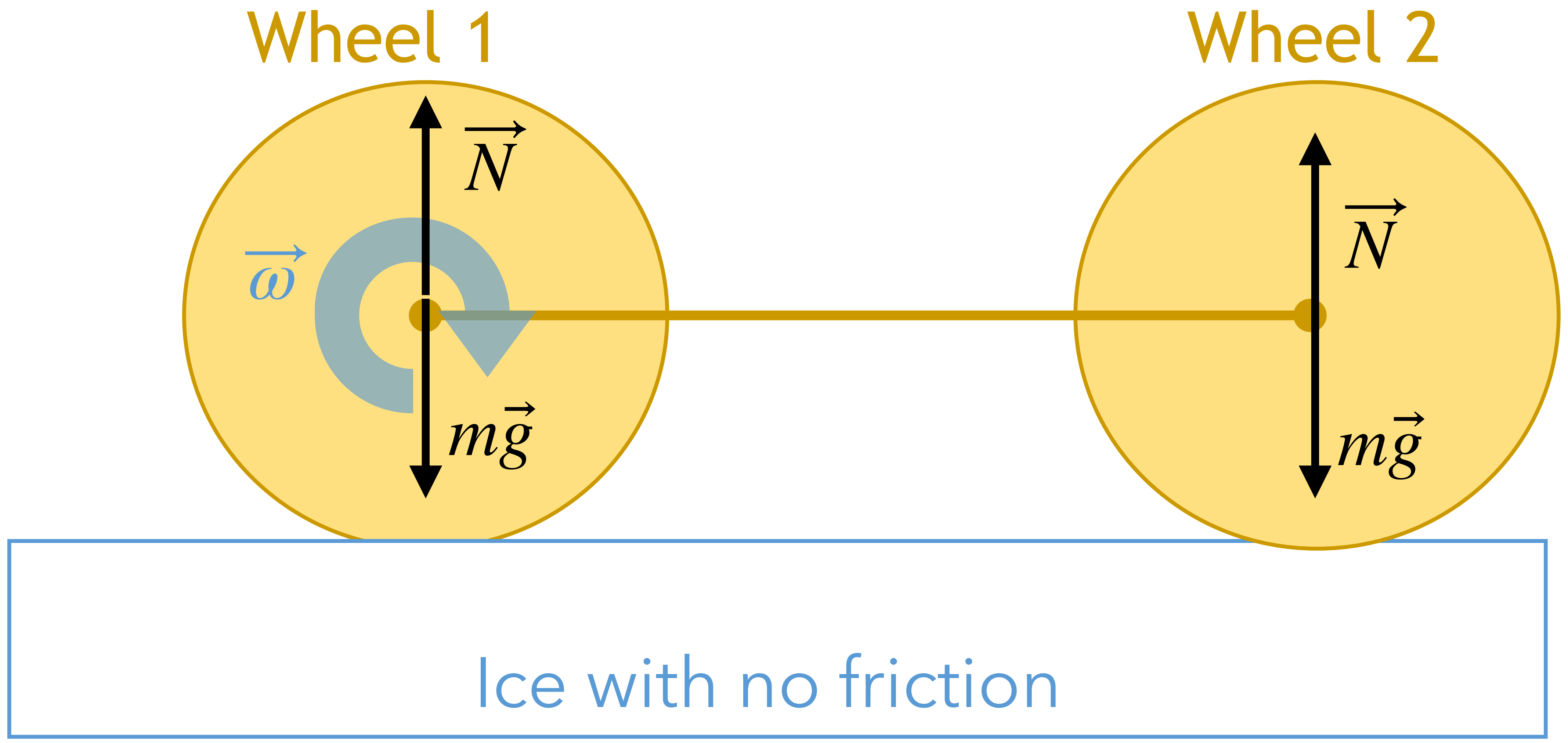
WORK & FRICTION

Work done by **static dry friction** $\overrightarrow{F}_S$

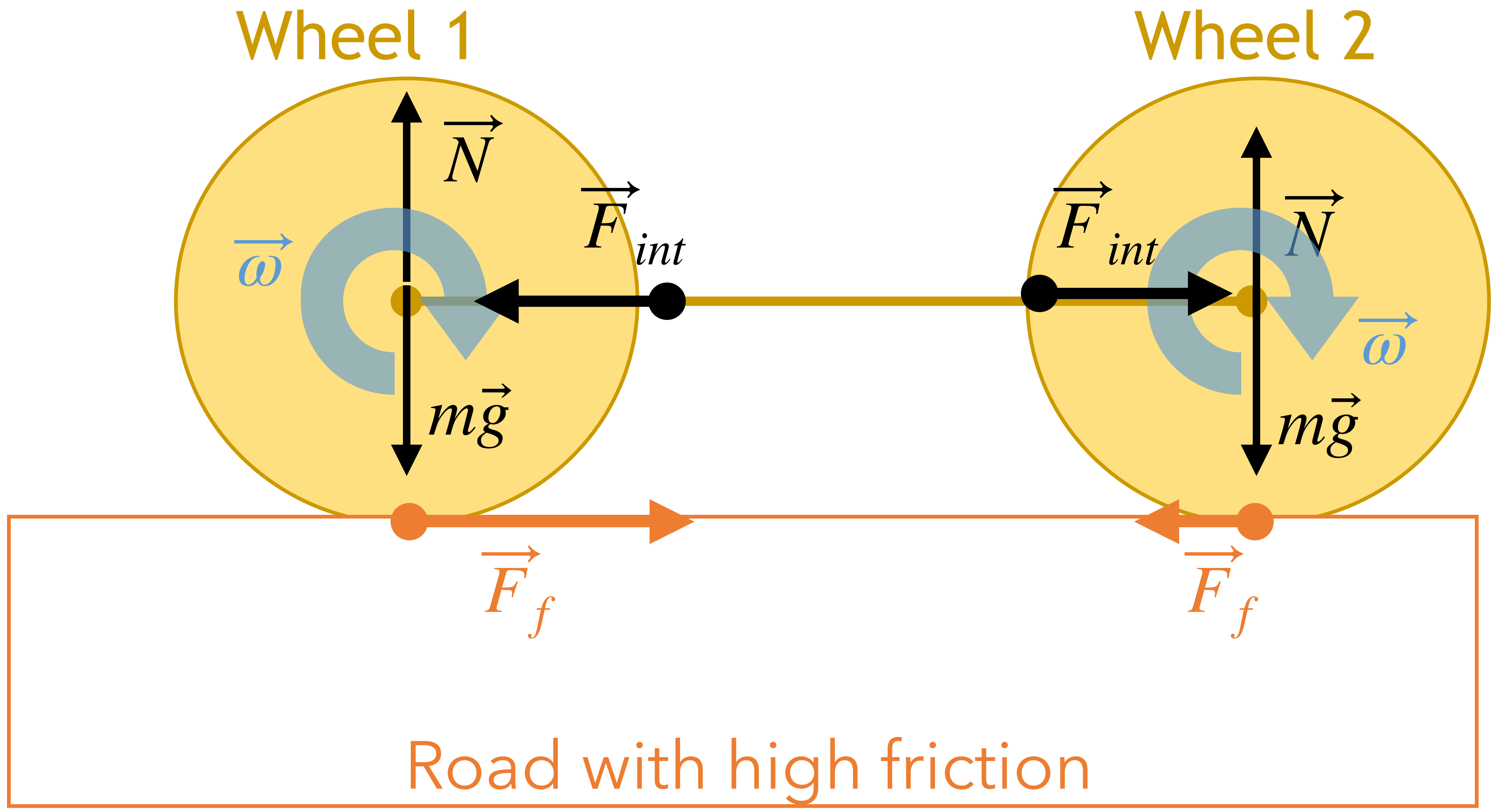
$$W_{AB}^{FS} = \int_A^B \overrightarrow{F}_S \cdot \overrightarrow{dr} = 0$$

By definition no motion with static friction… dr = 0!

WORK & FRICTION



WORK & FRICTION



WORK & FRICTION

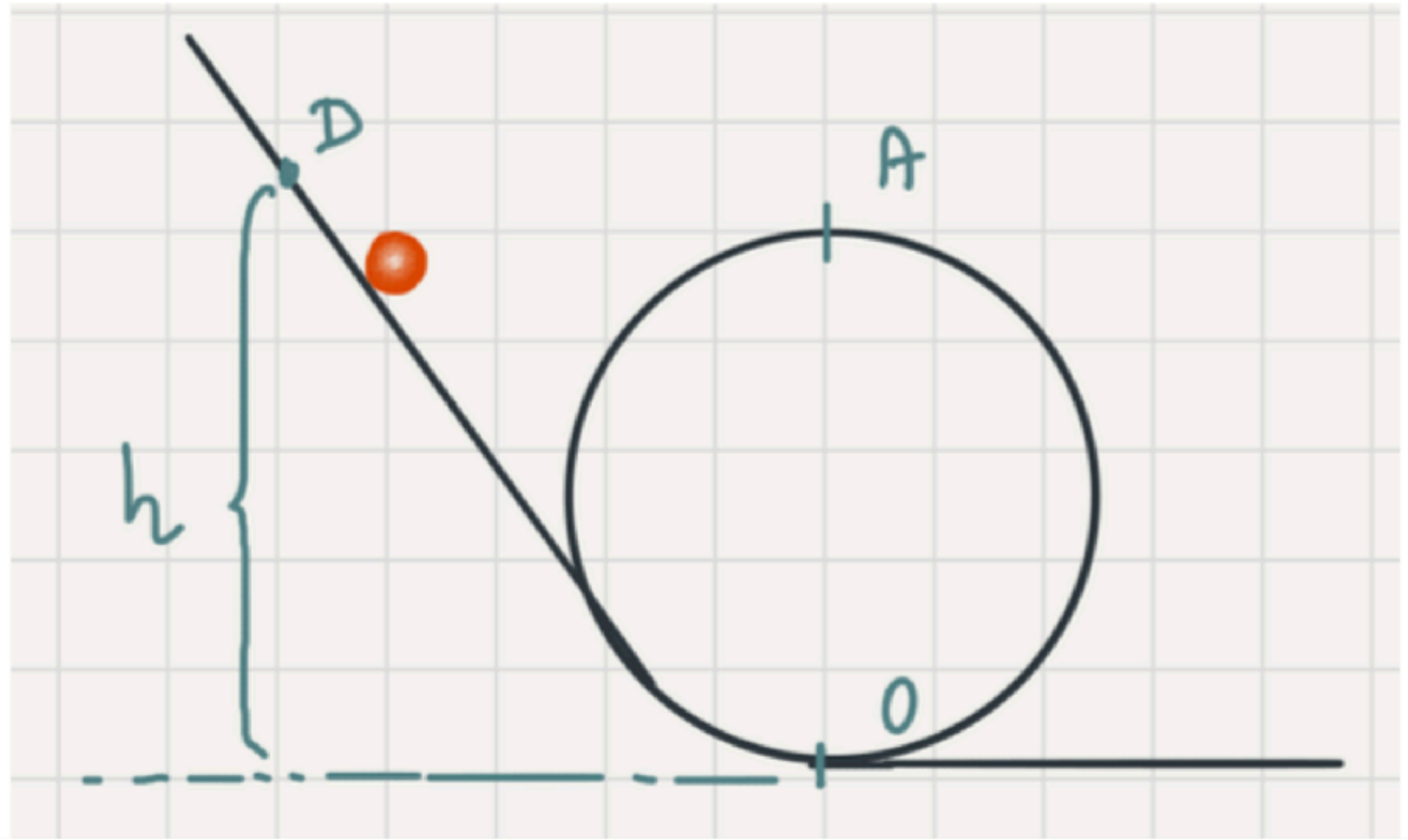
Work done by **laminar fluid friction** $\overrightarrow{F}_f$

$$W_{AB}^{Ff} = \int_A^B \overrightarrow{F}_f \cdot \overrightarrow{dr} = -\, b_l \int_A^B v\ dr$$

Can potentially be very complicated if the velocity varies

Almost always easier to use Newton's 2nd Law

EXERCISE



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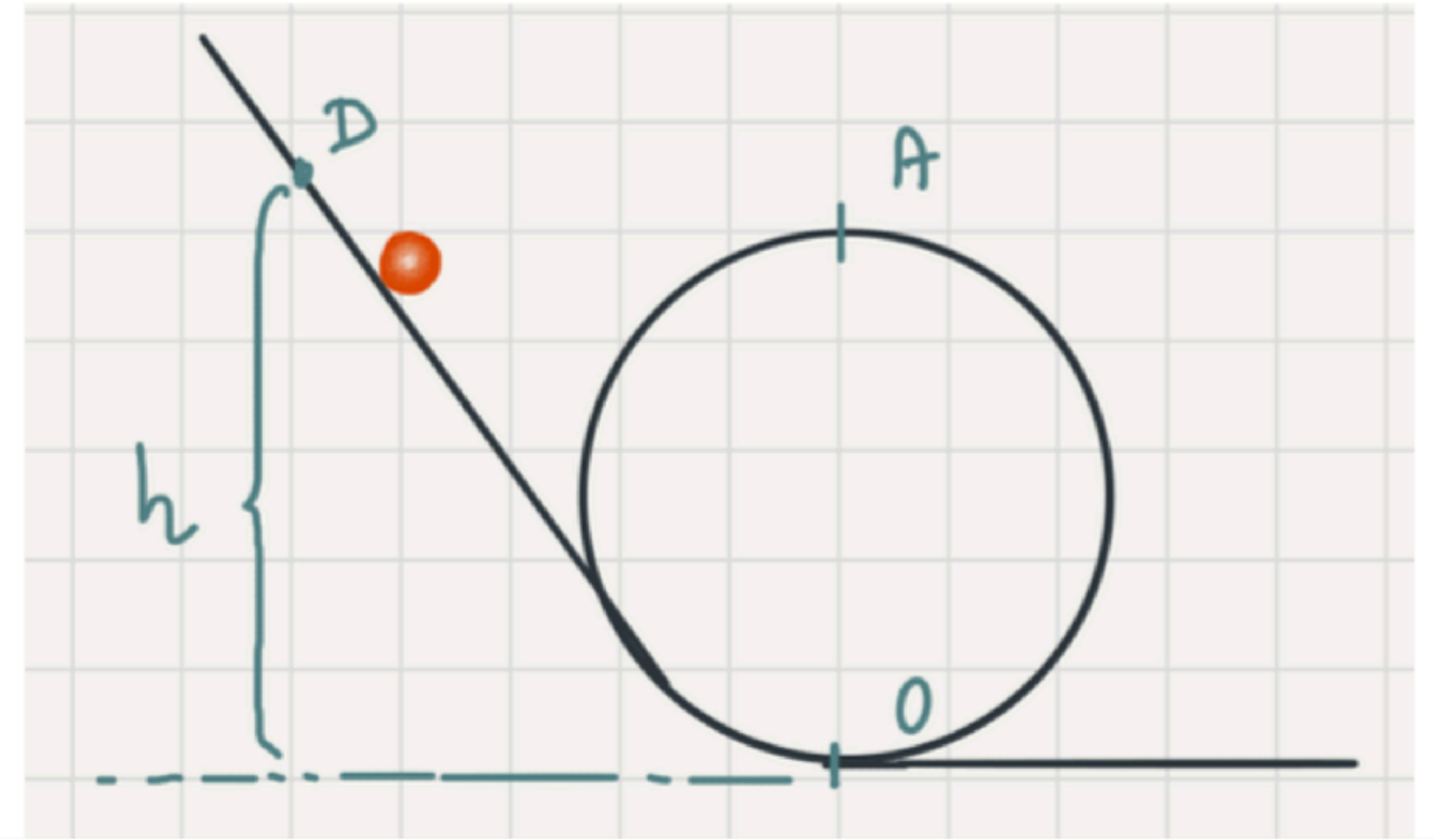

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A) What is the minimum starting height in terms of R so that the ball completes the loop without falling off the track?

B) What is the trajectory of the ball if it released from $h = 2R$?