Applications of Newtons laws

Ex. 6.4

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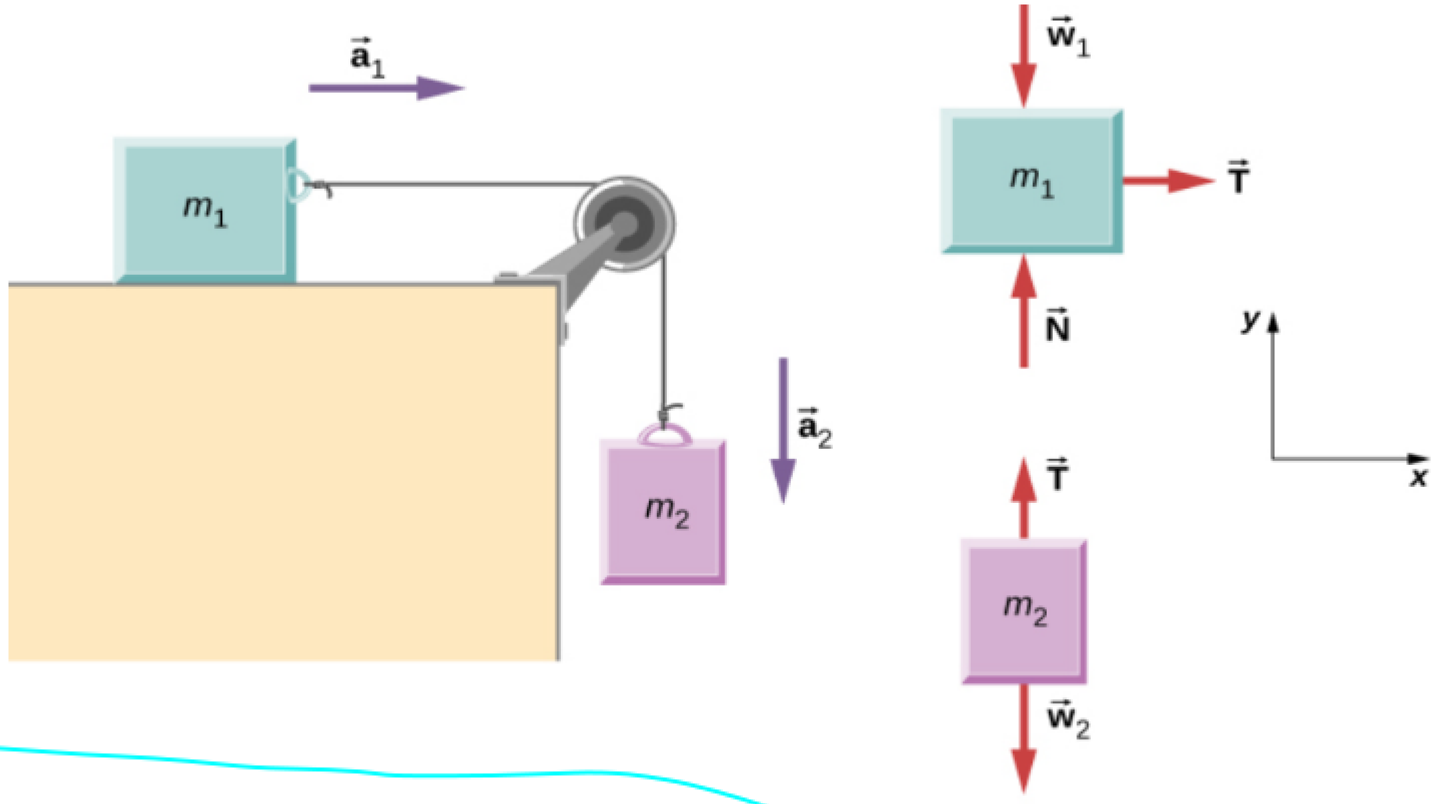

(a) (b)

No friction,
find a and T, knowing
m_1, m_2, and g

m_1:
$$\bar{T} + \bar{w}_1 + \bar{N} = m_1 \bar{a}_1$$

m_2:
$$\bar{T} + \bar{w}_2 = m_2 \bar{a}_2$$

$$|\bar{T}| = |\bar{T}|$$

1x:

$$T = m_1 a_{1x}$$

2y:

$$T - m_2 g = m_2 a_{2y} \quad , \quad a_{1x} = -a_{2y} = a$$

① $T = m_1 a$, ② $T - m_2 g = -m_2 a$

Two linear equations with two unknowns, T and a, solve together

①-② → $0 + m_2 g = m_1 a + m_2 a = (m_1 + m_2) a$

→ $(m_1 + m_2) a = m_2 g$ → $a = \left(\frac{m_2}{m_1 + m_2} \right) g$

use the result for a in ①

The system is accelerated

$$T = \frac{m_1 m_2}{(m_1 + m_2)} g$$

$$T \neq m_2 g$$

Friction - viðnámskraftar

Friction

Friction is a force that opposes relative motion between systems in contact.

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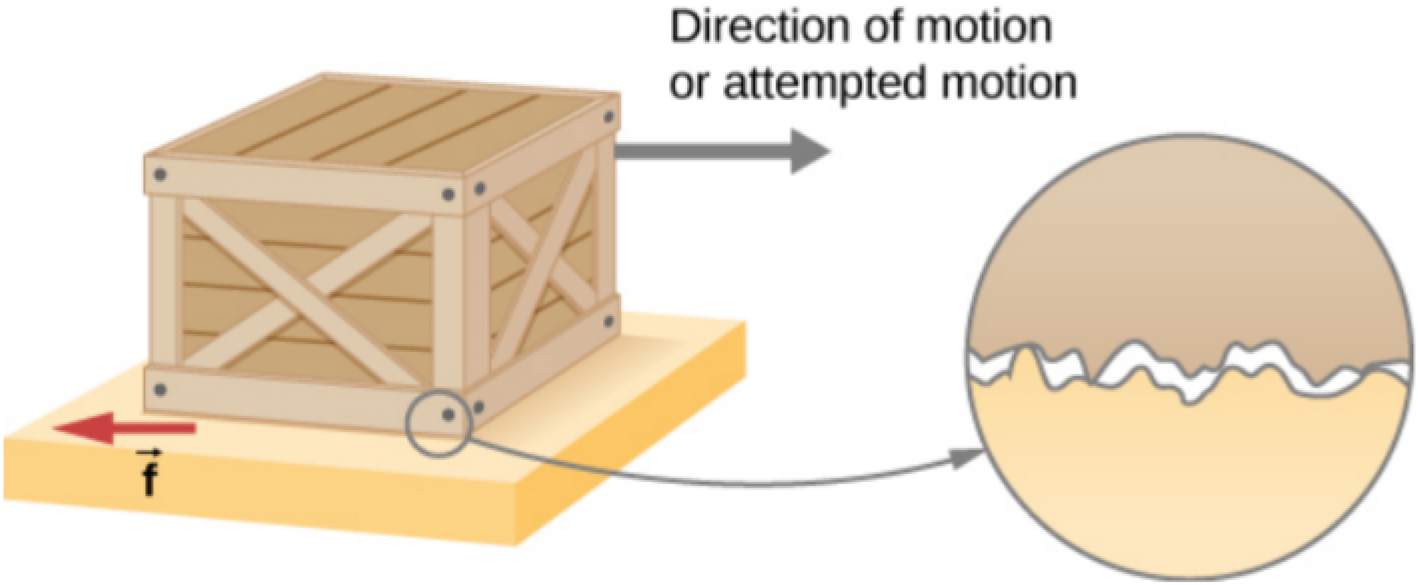
Static and Kinetic Friction

If two systems are in contact and stationary relative to one another, then the friction between them is called **static friction**. If two systems are in contact and moving relative to one another, then the friction between them is called **kinetic friction**.

④



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Magnitude of Static Friction

The magnitude of static friction f_s is

$$f_s \leq \mu_s N, \quad (6.1)$$

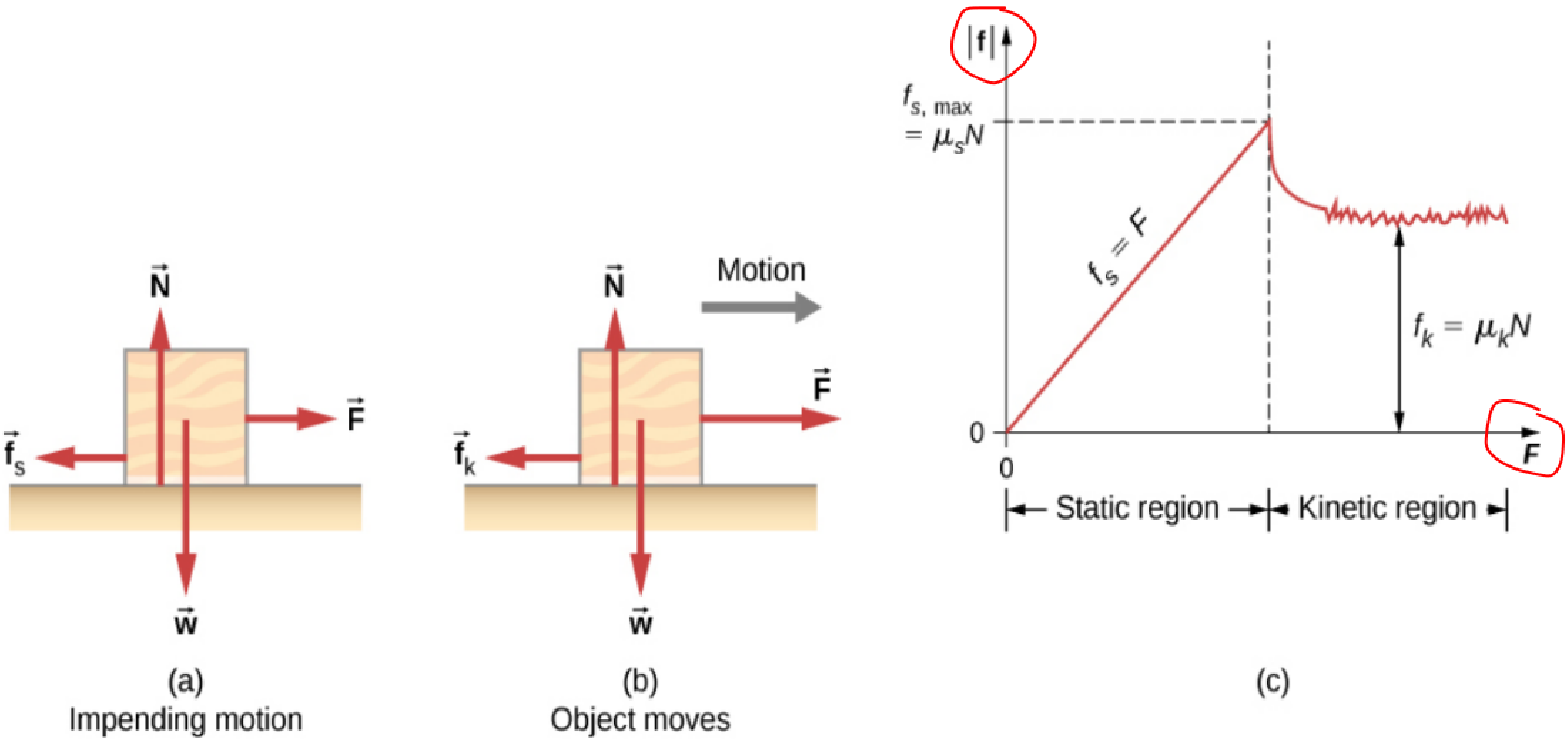
where μ_s is the coefficient of static friction and N is the magnitude of the normal force.

Magnitude of Kinetic Friction

The magnitude of kinetic friction f_k is given by

$$f_k = \mu_k N, \quad (6.2)$$

where μ_k is the coefficient of kinetic friction.



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Comparison of static and dynamic friction

6

System	Static Friction μ_s	Kinetic Friction μ_k
Rubber on dry concrete	1.0	0.7
Rubber on wet concrete	0.5-0.7	0.3-0.5
Wood on wood	0.5	0.3
Waxed wood on wet snow	0.14	0.1
Metal on wood	0.5	0.3
Steel on steel (dry)	0.6	0.3
Steel on steel (oiled)	0.05	0.03
Teflon on steel	0.04	0.04
Bone lubricated by synovial fluid	0.016	0.015
Shoes on wood	0.9	0.7
Shoes on ice	0.1	0.05
Ice on ice	0.1	0.03
Steel on ice	0.4	0.02

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Ex. 6.10

$M = 20\,kg$, $\mu_k = 0{,}600$

$\mu_s = 0{,}700$

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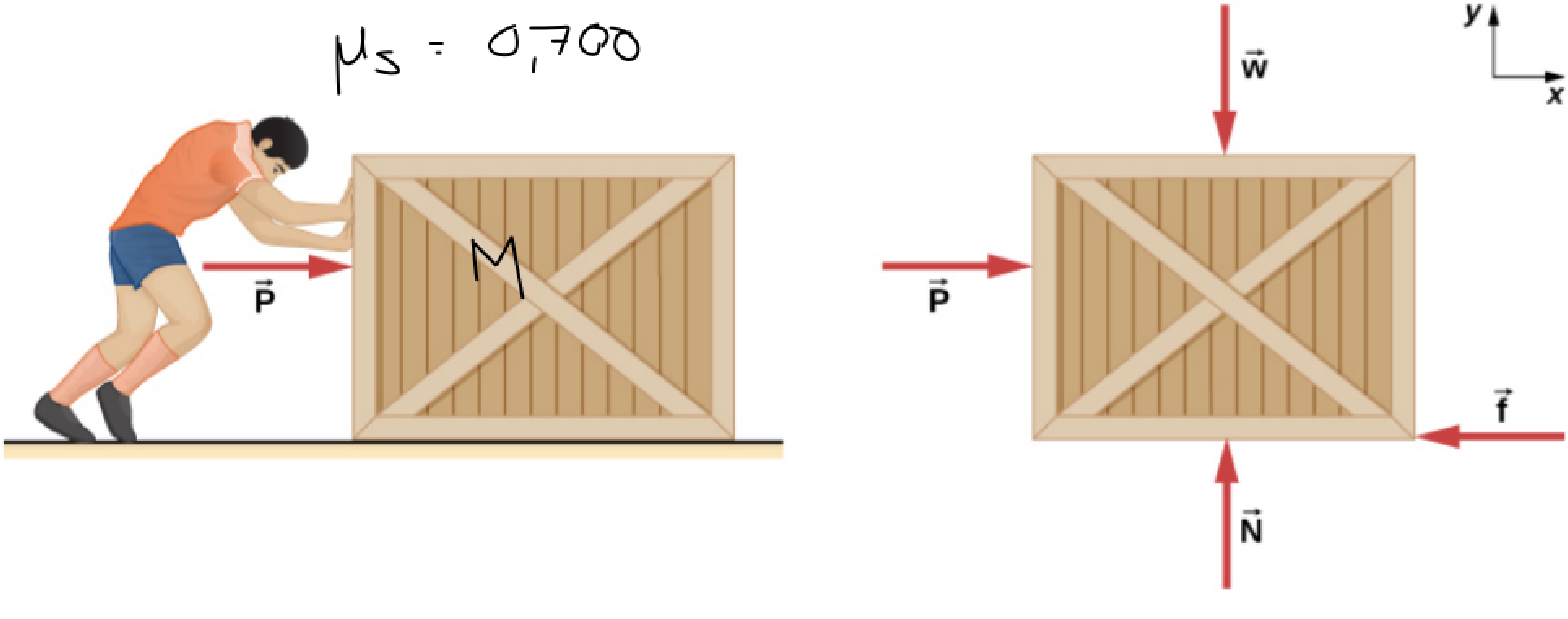

(a) (b)

Find f
a

y: $-mg + N = 0 = ma_y$

$\rightarrow N = mg$

x:

$$P - f = Ma_x \rightarrow a_x = \frac{P - f}{M}$$

$$N = w = mg \simeq 20 \cdot 9{,}81 \ \frac{km}{s^2} \simeq 196\,N$$

$$f_s \leq \mu_s N = 0{,}700 \cdot 196\,N \simeq 137\,N$$

$$f_k = \mu_k N = 0{,}600 \cdot 196 \simeq 118\,N$$

a) $P = 20\,N \rightarrow f_s = 20\,N$

b) $P = 30\,N \rightarrow f_s = 30\,N$

c) $P = 120\,N \rightarrow f_s = 120\,N$

d) $P = 180\,N$

$\downarrow$

$f_k = 118\,N$

$$a_x = \frac{P - f_k}{M} = 3{,}1\,\frac{m}{s^2}$$

Centripetal force - miðsóknarkraftur

For steady circular motion we had

$$a_c = \frac{v^2}{r} = r\omega^2$$

radial inward directed acceleration needed to maintain the motion

→ $$F_c = m a_c$$

$$= m\frac{v^2}{r}$$

$$= m r \omega^2$$

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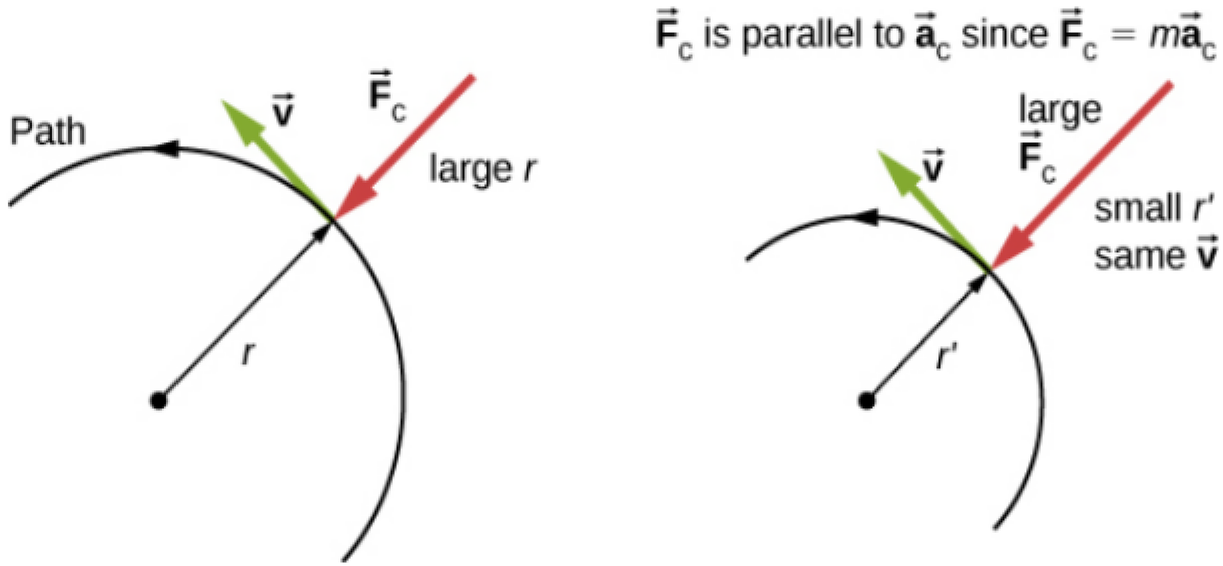

Ex. 6.15

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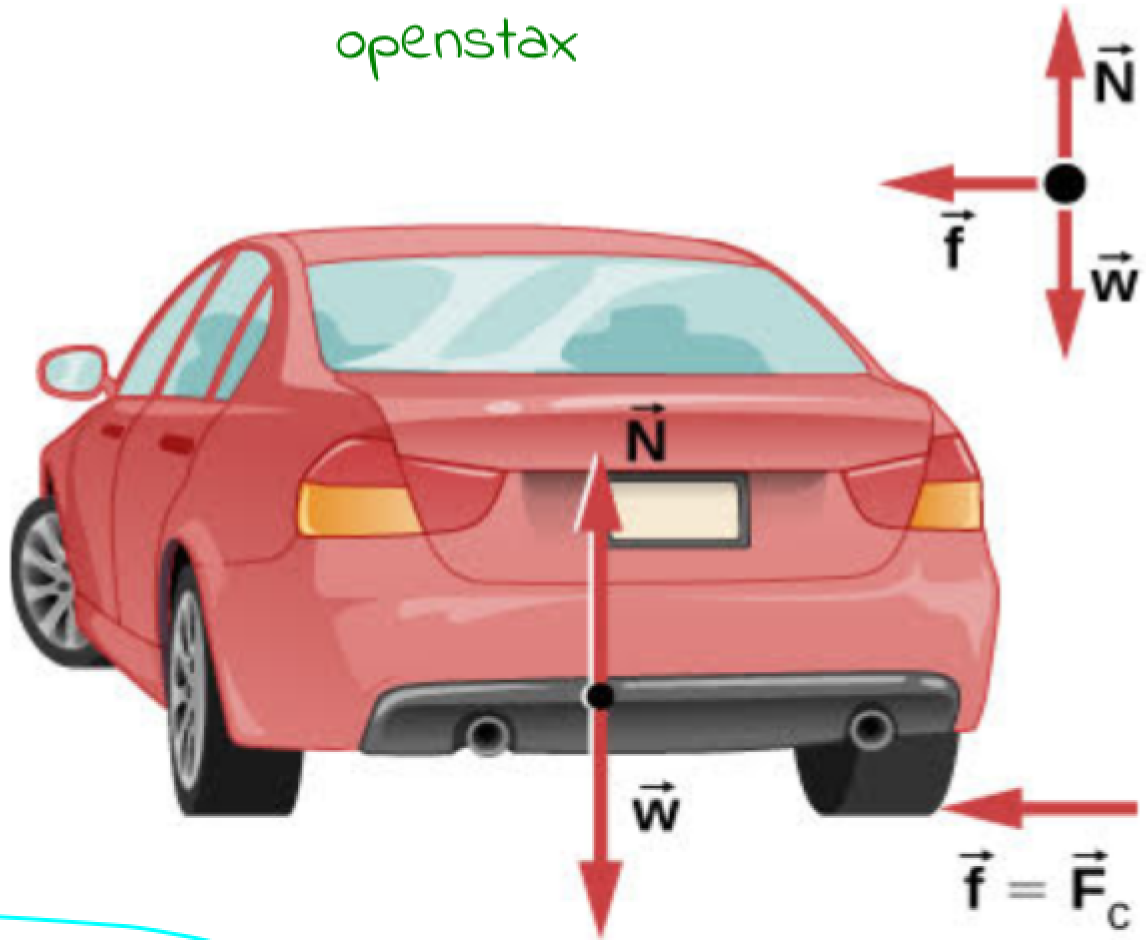
Car $M = 900$ kg

500 m - radius curve

at 25 m/s

Find needed μ_s for no slip



$$F_c = mv^2/r$$

$$F_c \equiv f = \mu_s N = \mu_s mg \rightarrow \frac{mv^2}{r} = \mu_s mg$$

$$\rightarrow \mu_s = \frac{v^2}{rg}$$

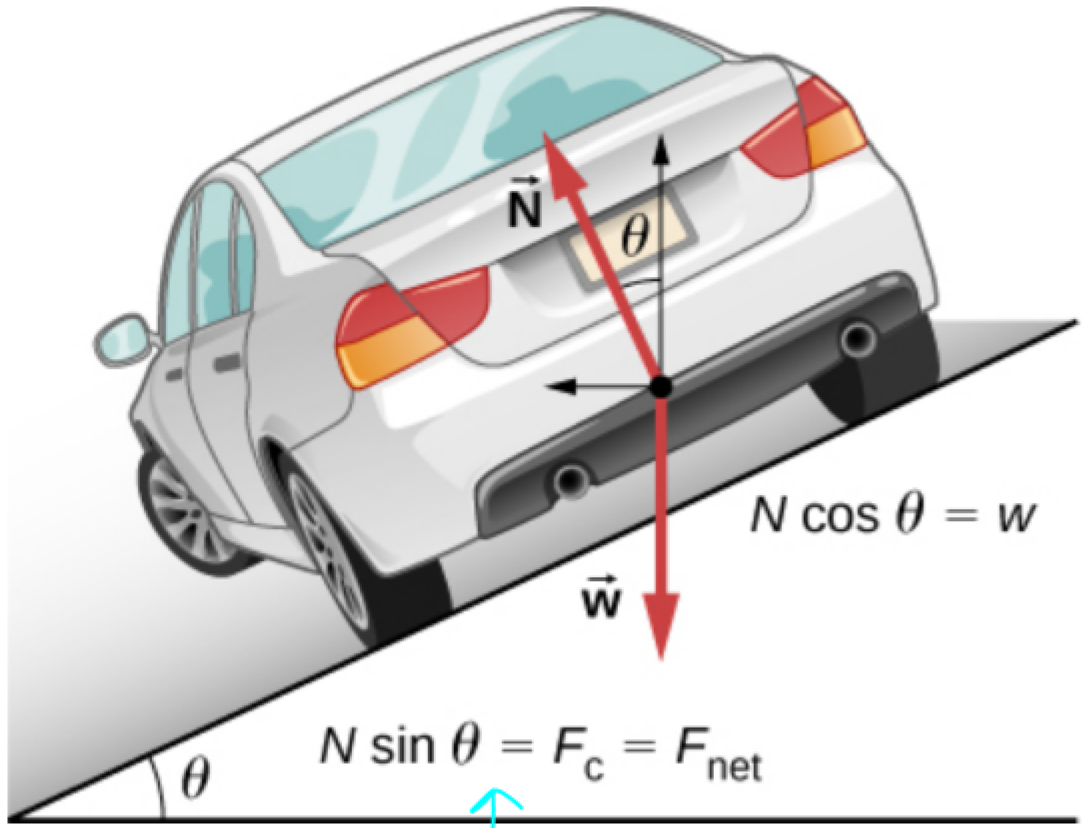
$$\mu_s = \frac{v^2}{rg} = \frac{25^2}{500 \cdot 9{,}81} = 0{,}13$$

this is lower than usually the real coefficient for tire and asphalt, so OK,
but it is better so ...
The mass cancels!

Banked curve, why?

Ideal banking

the needed Fc comes from the banking



We have

$$N\sin\theta = \frac{mv^2}{r}$$

$$N\cos\theta = mg \longrightarrow N = \frac{mg}{\cos\theta}$$

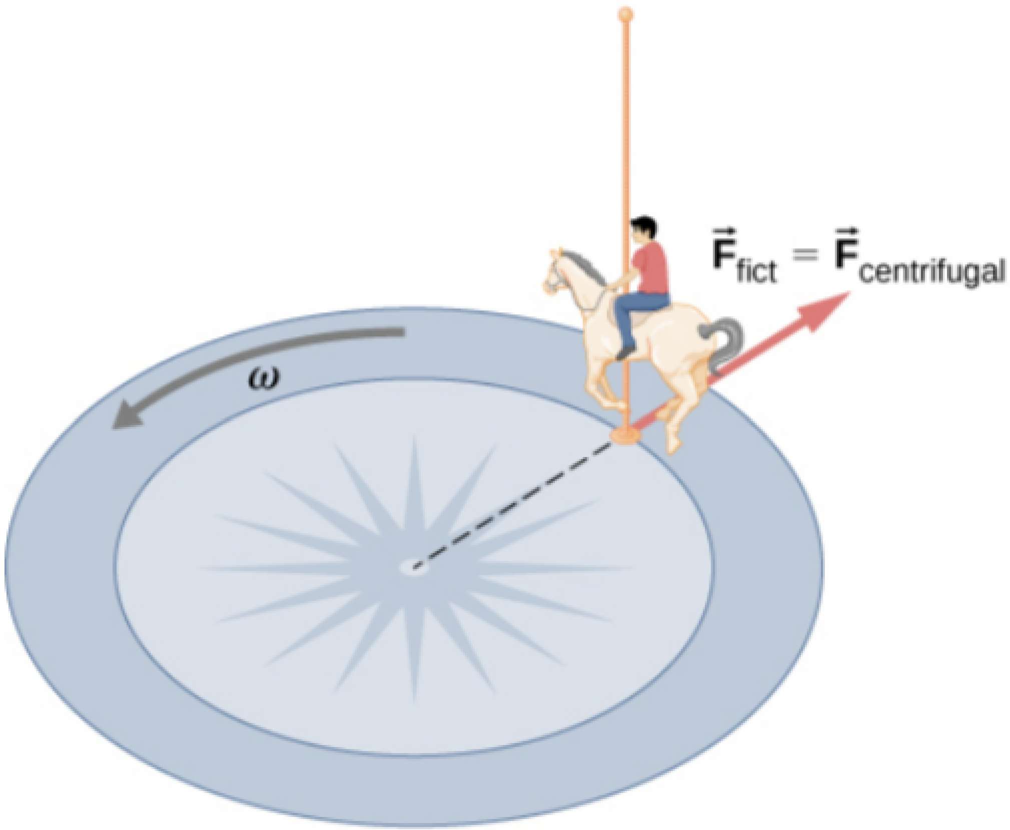
$$mg\tan\theta = \frac{mv^2}{r}$$

$$\longrightarrow \tan\theta = \frac{v^2}{rg}$$

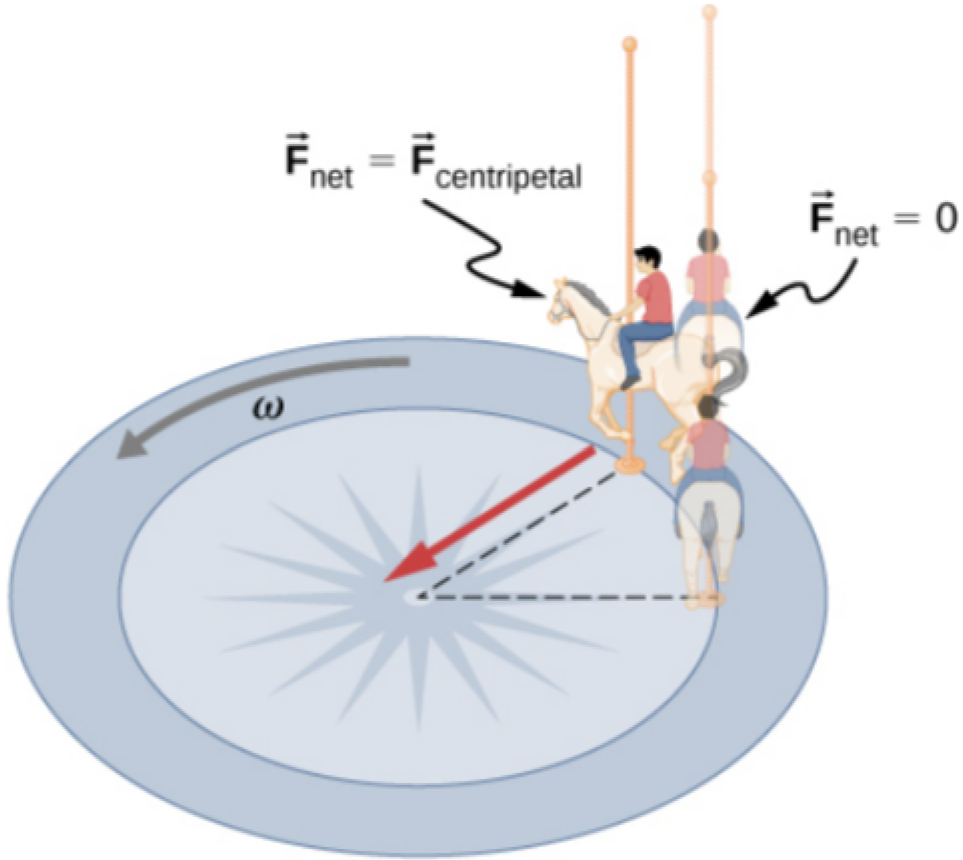
$$\longrightarrow \boxed{\theta = \arctan\left[\frac{v^2}{rg}\right]}$$

no m

Pseudoforce -- centrifugal force in noninertial systems



Merry-go-round's rotating frame of reference



Inertial frame of reference

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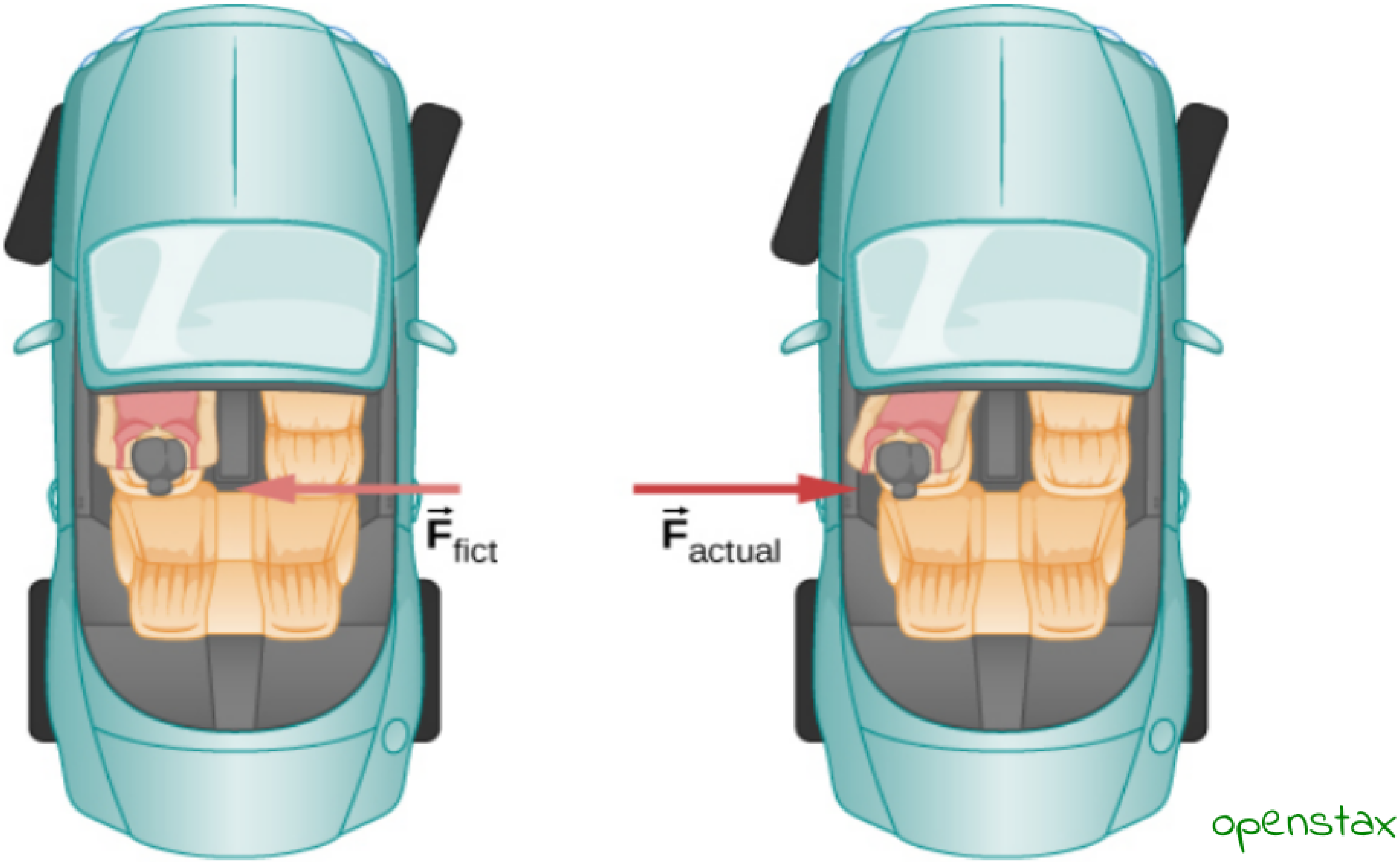

rotating system

inertial system

Pseudoforce - Coriolis force (noninertial system)

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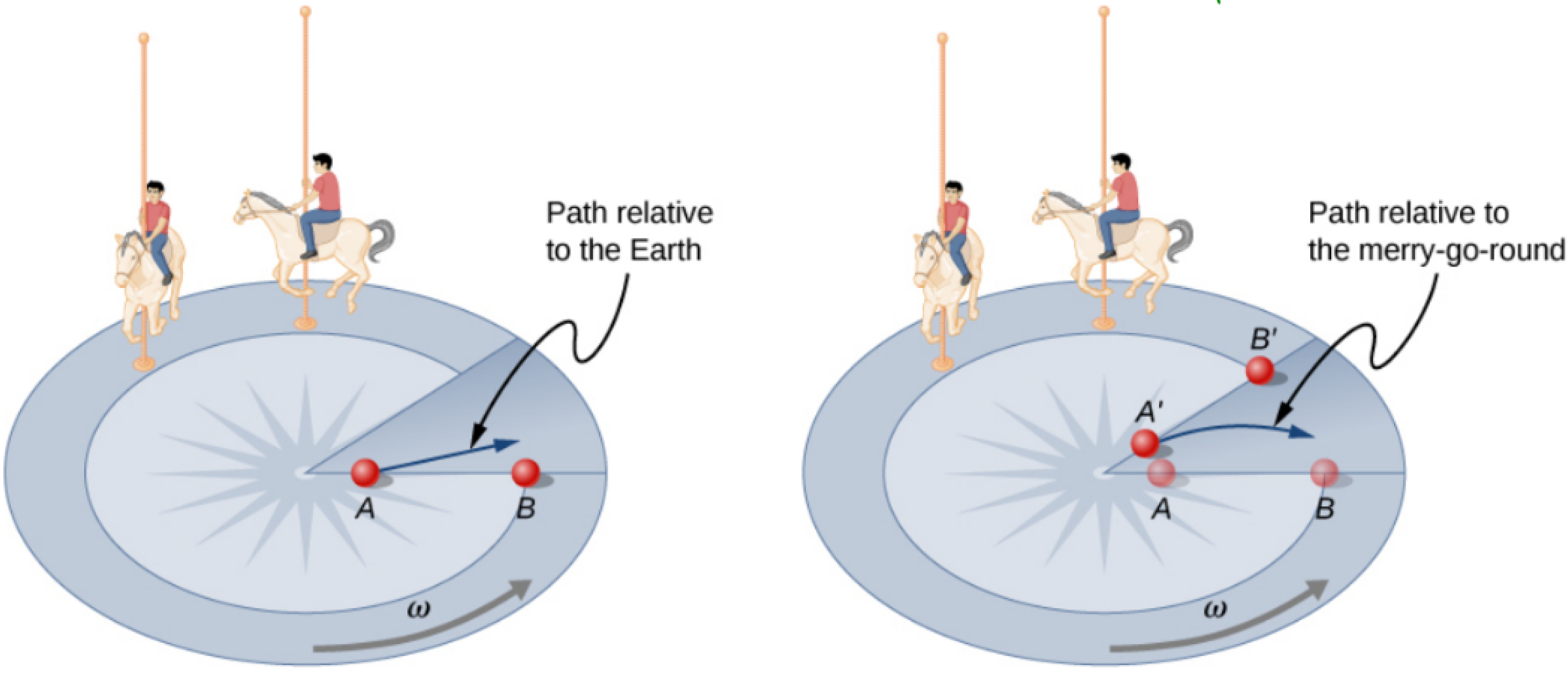
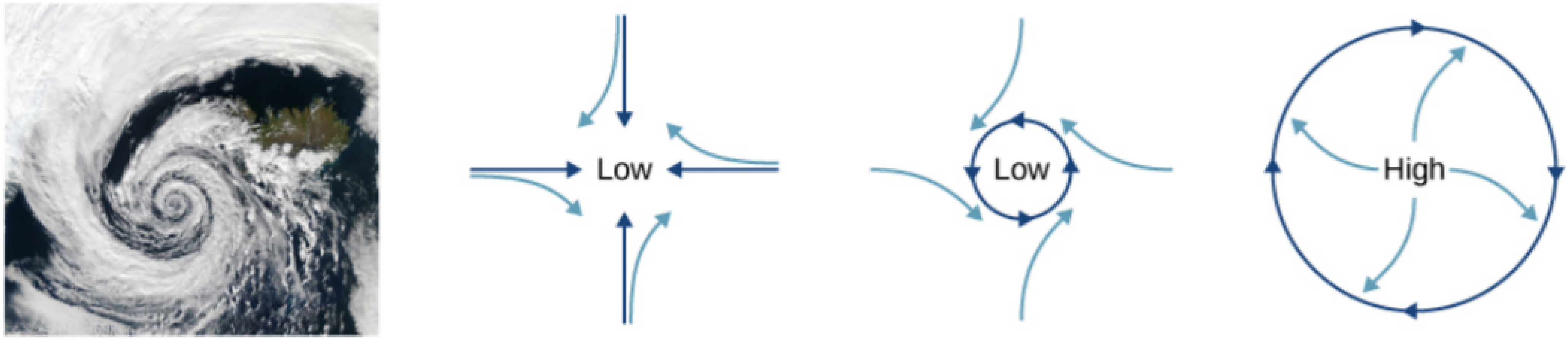


(a) (b)



(a) (b) (c) (d)

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