No labs today

Please, login into webassing, locate LectureMCQ_L17 (PY105) and answer question 1 (but ONLY Q1!).

Pleas sign in using the sign-in sheets on the bench. Thank you

Note: exam room change:
Exams 2, 3 take place in STO B50

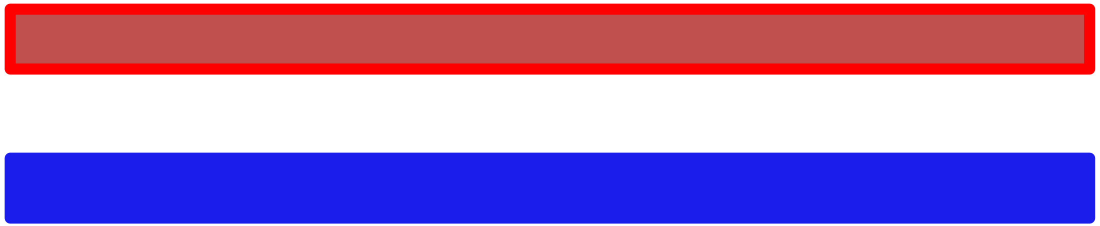
Good morning!

Webassign: L17 Q2

Which rod has the mass closer to the middle point?

1. The red one
2. The blue one

Webassign: L17 Q2



Which rod has the mass closer to the middle point?

1. **The red one**
2. **The blue one**

The same conic pendulum is used twice (see the pictures).

Case 1

Case 2

Webassign: L17 Q3

In which case the ball spins faster?

1. Case 1

2. Case 2

The same conic pendulum is used twice (see the pictures).

Case 1

[Webassign: L17 Q3]

Case 2

In which case the ball spins faster?

1. Case 1

2. Case 2

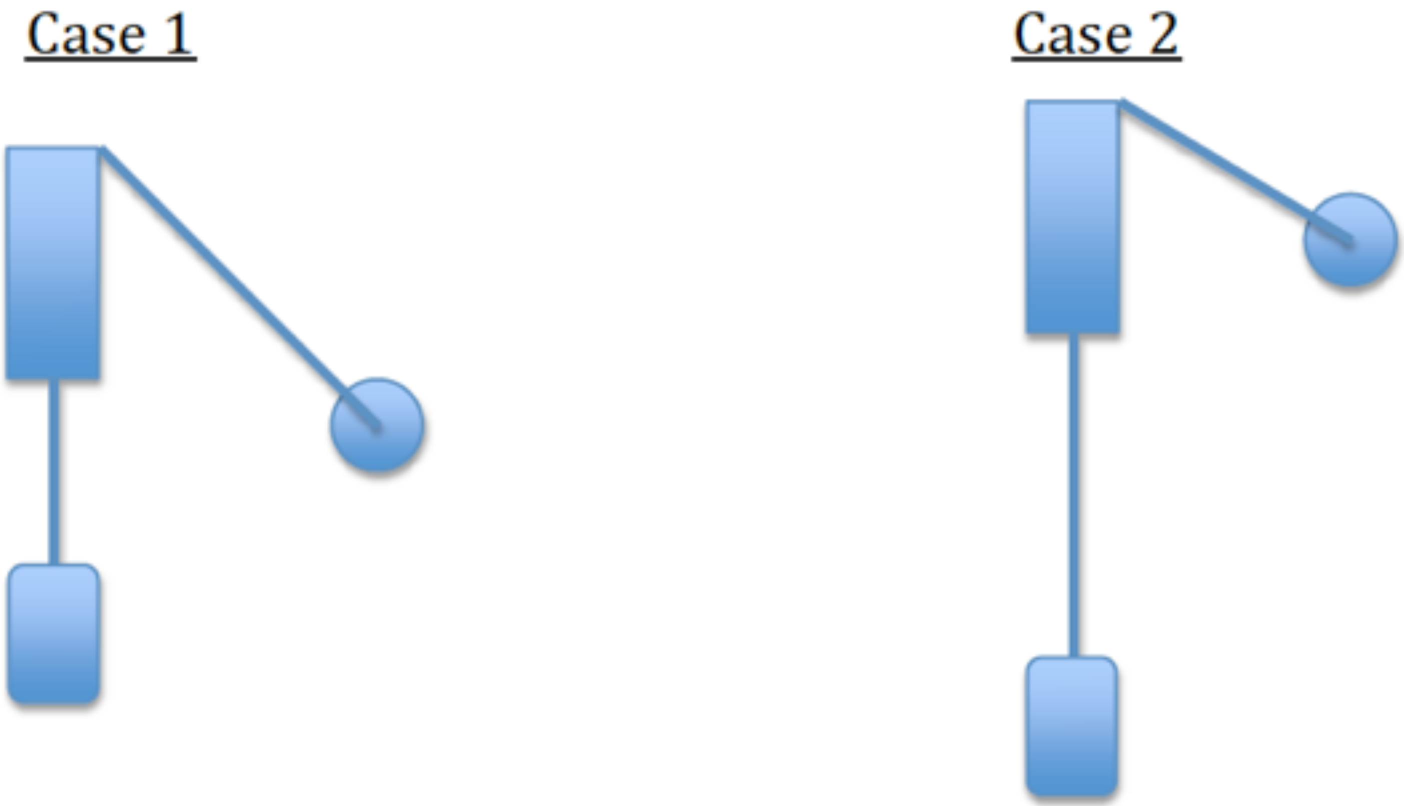
$$L_i = L_f$$

$$\Downarrow$$

$$I_1 \omega_1 = I_2 \omega_2$$

$$r\downarrow \Rightarrow \downarrow I \quad \uparrow \omega$$

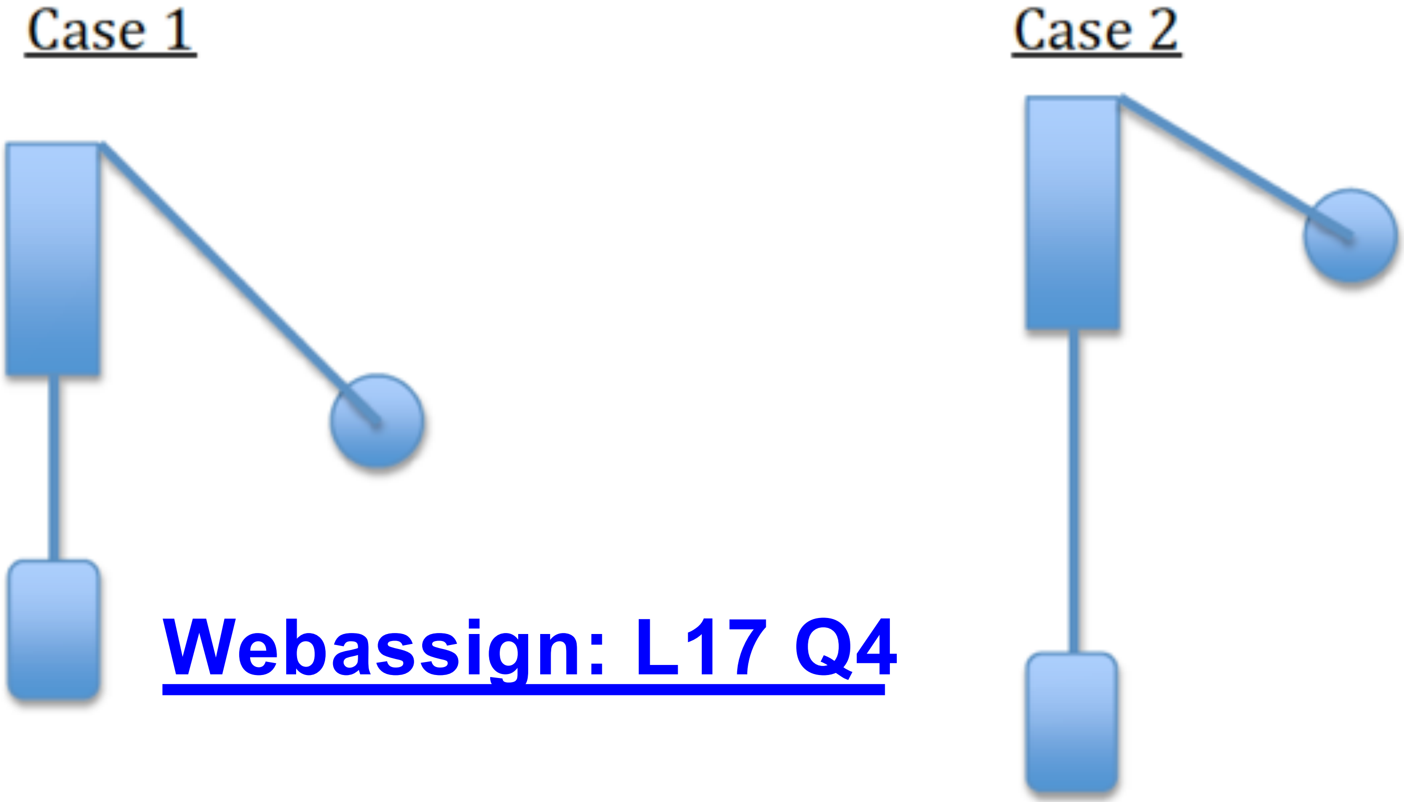
The same conic pendulum is used twice (see the pictures).



In which case the ball spins faster?

1. Case 1
2. Case 2

The same conic pendulum is used twice (see the pictures).



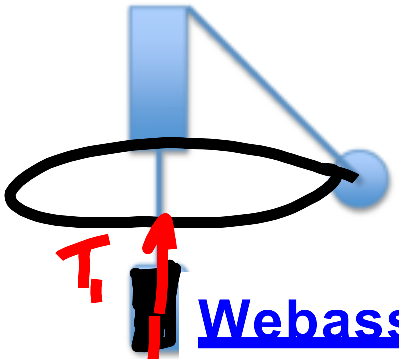
Webassign: L17 Q4

In which case is the tension in the string larger?

1. Case 1
2. Case 2
3. The tension is the same

The same conic pendulum is used twice (see the pictures).

Case 1 | Case 2

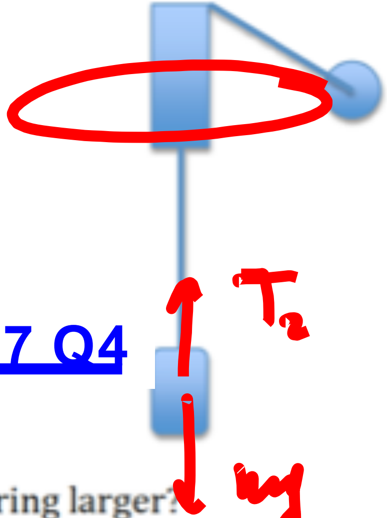


T_1

mg

$v = 0, a = 0$

[Webassign: L17 Q4]



T_2

mg

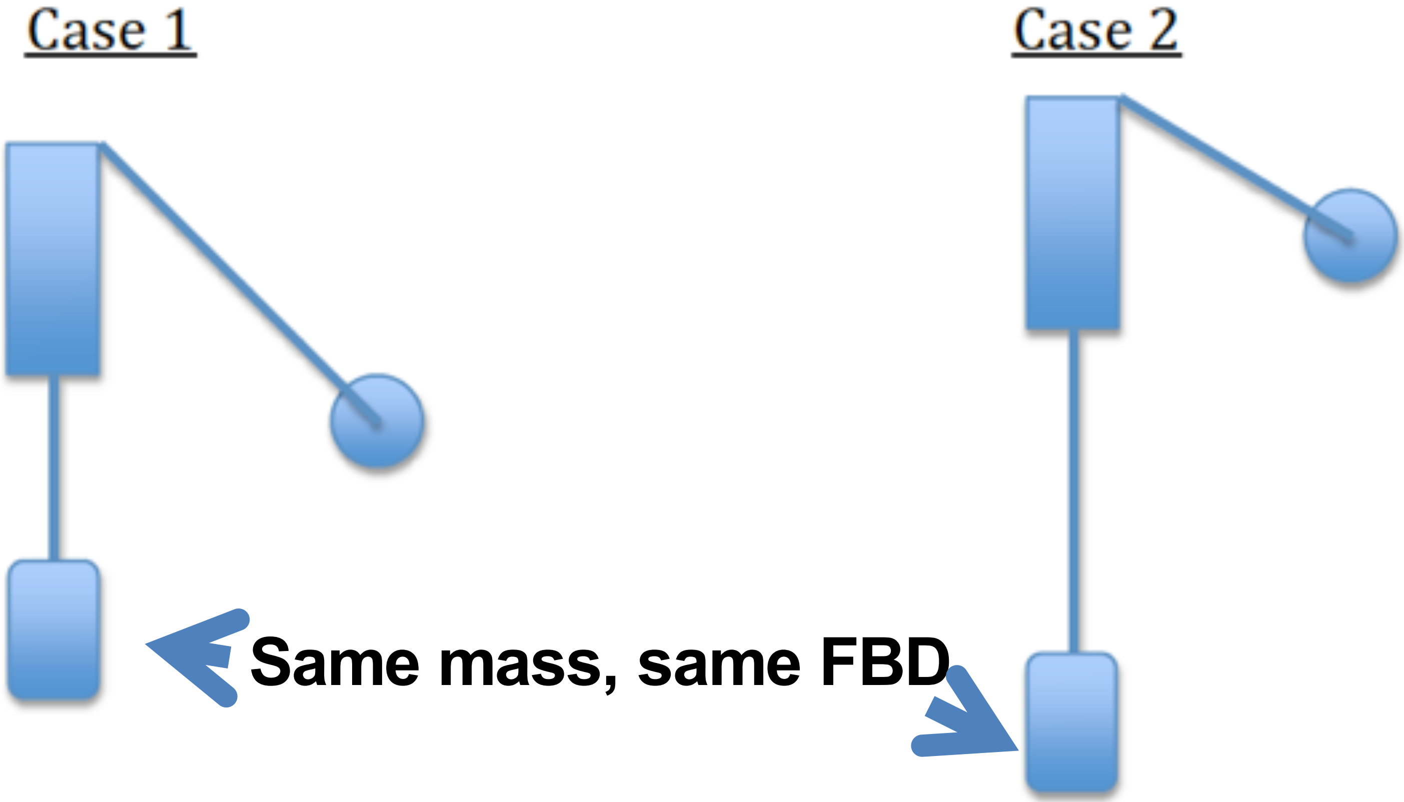
$T_1 = mg$

$T_2 = mg$

In which case is the tension in the string larger?

1. Case 1   2. Case 2   3. The tension is the same

The same conic pendulum is used twice (see the pictures).



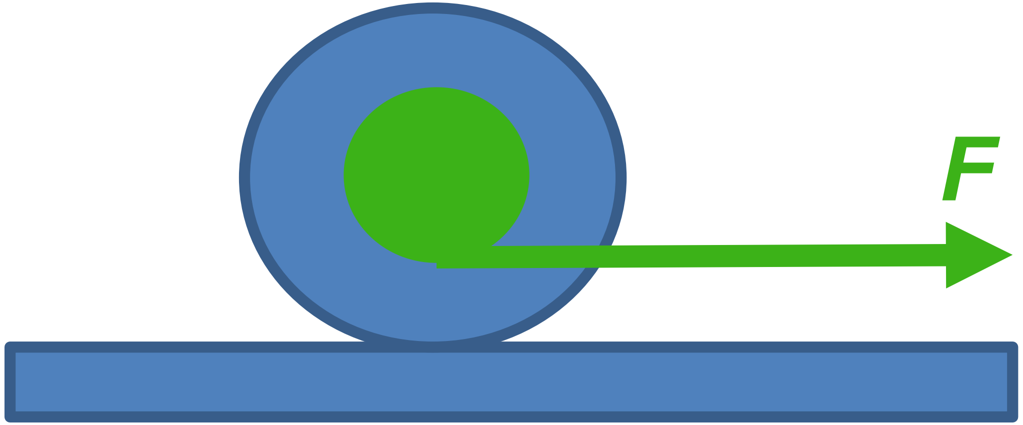
In which case is the tension in the string larger?

1. Case 1
2. Case 2
3. The tension is the same

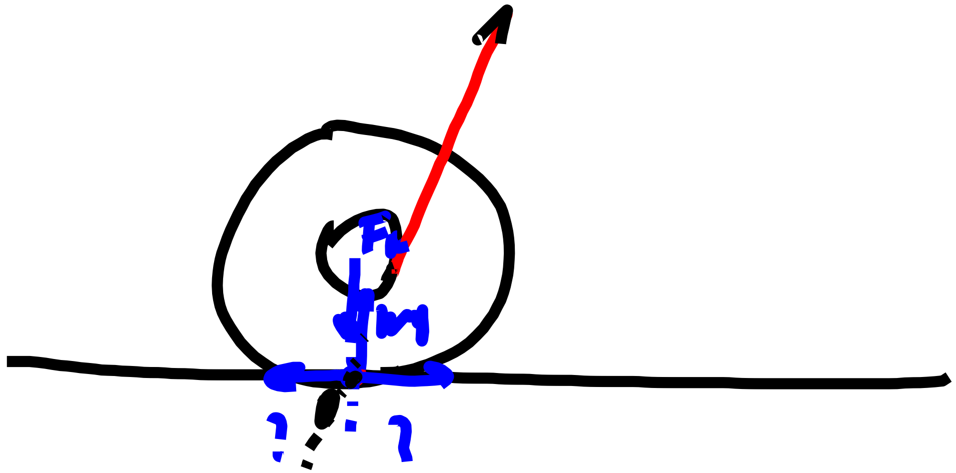
A spool is being moved from rest with the means of a string wound about it and slowly puled in a horizontal direction as shown.

If friction prevents the spool from slipping, the spool will be rotating …

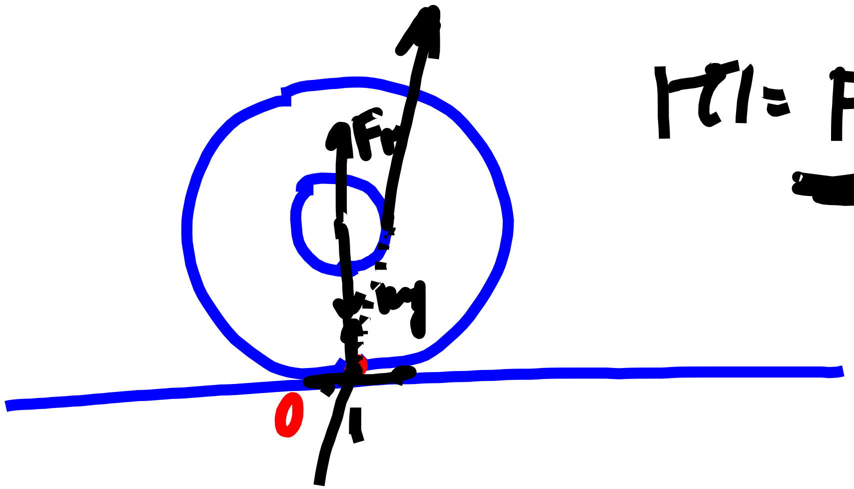
1. CCW
2. CW
3. Not enough information to answer



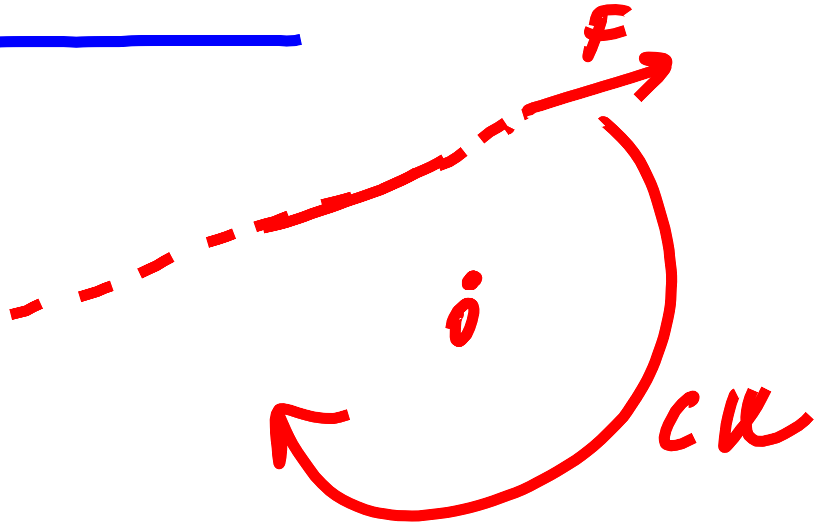
Webassign: L17 Q5



mg



$|\tau| = F \cdot l = F \cdot 0 = 0$



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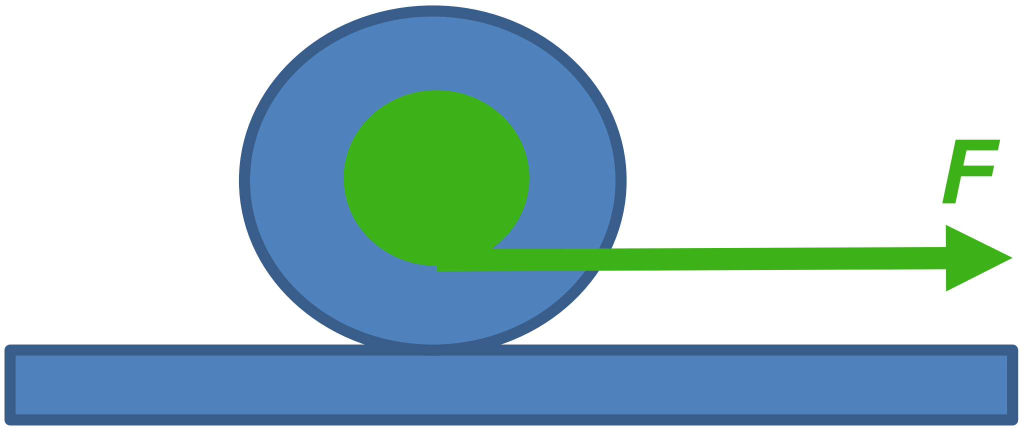
If friction prevents the spool from slipping, the spool will be rotating …

1. CCW
2. CW
3. Not enough information to answer



Webassign: L17 Q5

A front-wheel car starts moving from rest to the right.

Webassign: L17 Q6

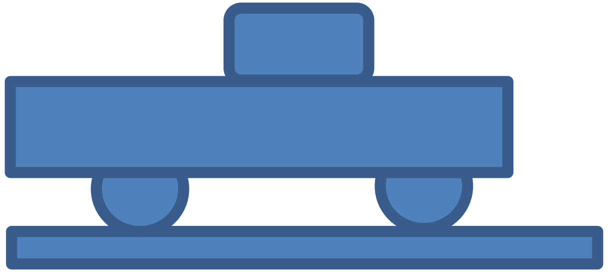
The force of friction acting from the ground on the front wheels points …

1. To the right. 2. To the left

Webassign: L17 Q7

The force of friction acting from the ground on the rear wheels points …

1. To the right. 2. To the left



A front-wheel car starts moving from rest to the right.

Webassign: L17 Q6

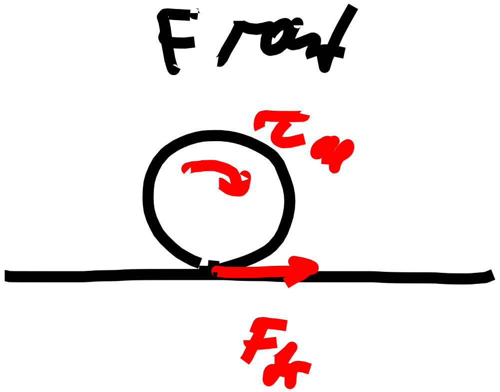
The force of friction acting from the ground on the front wheels points …

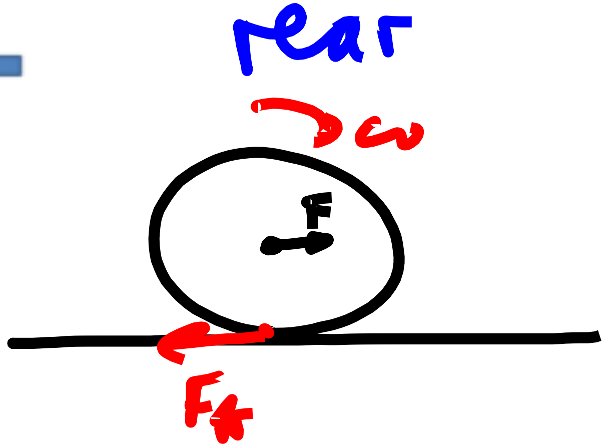
1. To the right. 2. To the left

Webassign: L17 Q7

The force of friction acting from the ground on the rear wheels points …

1. To the right. 2. To the left





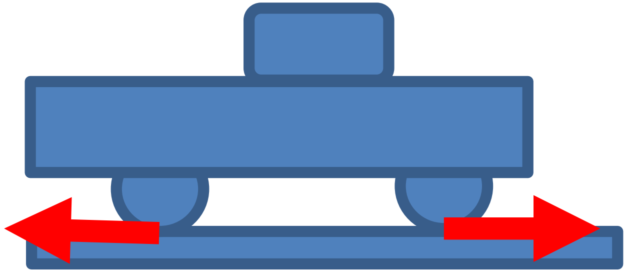
A front-wheel car starts moving from rest to the right.

The force of friction acting from the ground on the front wheels points …

1. To the right. 2. To the left

The force of friction acting from the ground on the rear wheels points …

1. To the right. 2. To the left



Physical terms/parameters/quantities used to describe motion:

position, trajectory, path, origin, reference frame, coordinate, position vector, radius-vector, displacement, magnitude of the displacement, distance traveled, time of motion, elapsed time, average velocity, average speed, instantaneous velocity, instantaneous speed,

=> need to know each definition *literally*!

General Problem solving strategy for problems on N2L

1. Read, imagine what is happening
2. Draw a picture, select your system (an object or objects)
3. For each system draw FBD, show all important forces, directions, vectors, quantities (known and unknown)
4. Add the reference frame (x- y- axes, the origin)
5. Write N2L for each system/object (for both components, attention to +/-).
6. Write kinematical equations (Eq., MCV, MCA).
7. Do the math

Circular and Rotational motion, Rolling:

Linear and angular variables, Centripetal acceleration, Moment of inertia, N2LforRM, RKE, Angular momentum, Work of torque

Some helpful questions for solving physics problems (page # 12)

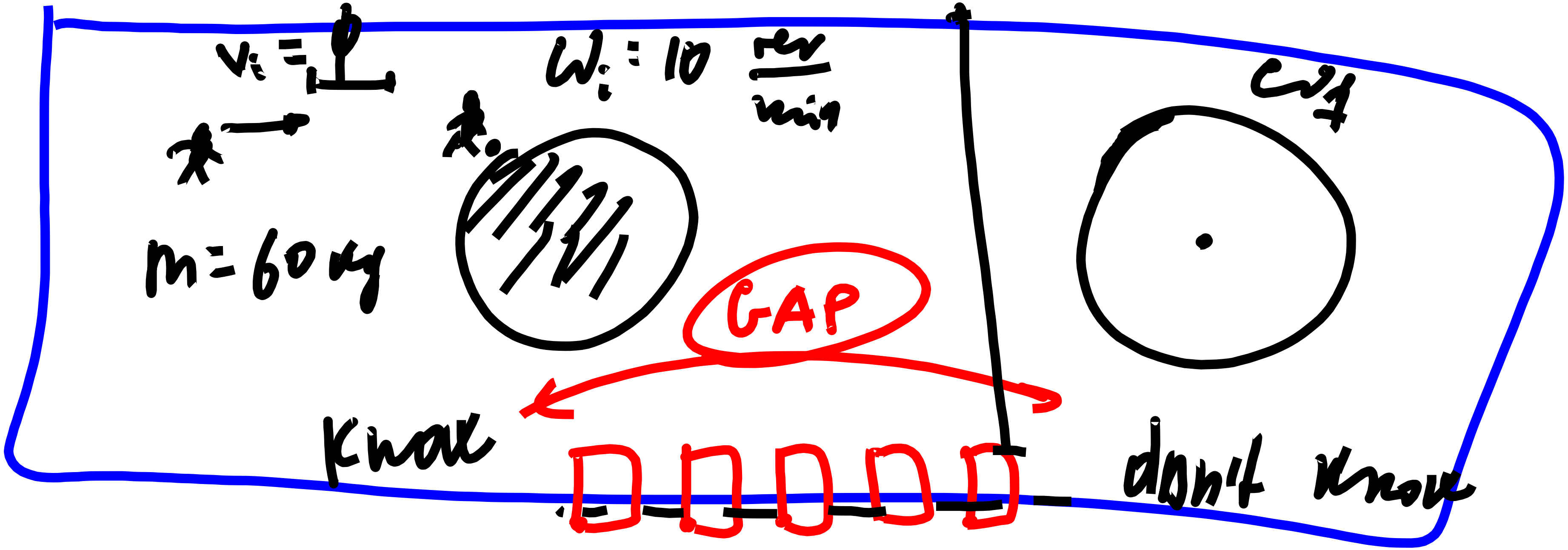
1. What objects are involved? What processes are happening to them? (use your imagination - make a picture showing the objects and the processes they are involved into)
2. What properties of the objects and the processes might be important?
3. What physical quantities should be used for describing those properties, what connections might be important?
5. What laws or definitions should be used to describe important connections mathematically?
6. How can I solve my equations mathematically?
8. Does it make a sense?
9. Could I solve a similar problem again? How much time would it take? Who could help me (if I need it)?

http://teachology.xyz/general_algorithm.htm

General strategy for using TBE.

1. Picture
2. Convert picture into a diagram: FBD
3. Convert FBD into torque-diagram by SETTING the axis of rotation
4. Write the actual value (a.c.a a component) for torque of each force relative to the same axis
5. Set TBE and solve it
6. If needed, select another axis or use FBE

Friction, Energy and Work, momentum, collisions: Kinetic and static friction, work of a constant force, kinetic and potential energy, WKET, LCME, LCLM.

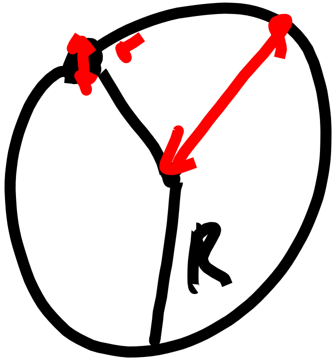


1) DA ∝ L_{qw} → 2NL

2NLR

LCE LCLM LCAM

ω_i dist...



LCAM: $L_i = L_f$

$$\downarrow$$

$$I_i \omega_i = I_f \omega_f$$

$r \lll R$

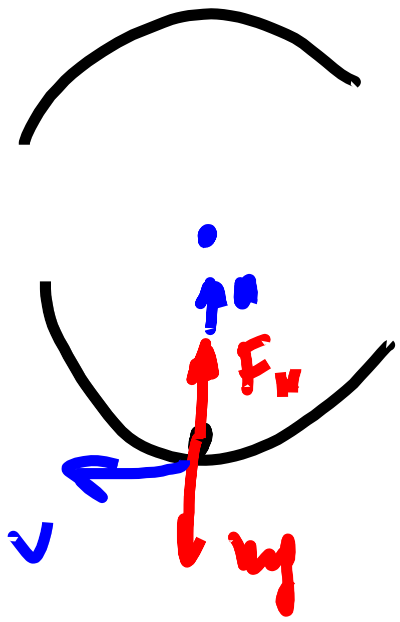
$r \sim 0$

What can I do NOW?

$$I_i = I_d = \frac{1}{2} M R^2;$$

$$I_f = I_d + m R^2$$

$$\frac{1}{2} M R^2 \cdot \omega_i = \left(\frac{1}{2} M R^2 + m \cdot R^2 \right) \cdot \omega_f$$

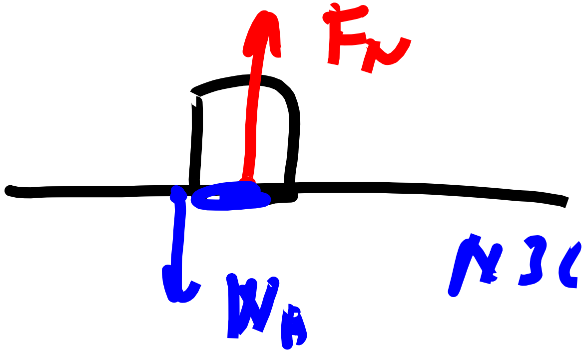


N2L

$$F_N - mg = m \cdot a$$

$$W_A = ?$$

F_N ; mg ; $ma = m\frac{v^2}{R}$



N3L

$$W_A = F_N$$

$$= m\frac{v^2}{R} + mg$$

$$-mg - F_N = -ma$$

$$F_N = ma - mg$$

$$\Downarrow$$

$$W_A = F_N = m\frac{v^2}{R} - mg$$

If: $v \downarrow$

$$\Downarrow$$

$$\underline{\underline{F_N = 0}}$$

at $\underline{v_c}$

$$0 = \frac{mv_c^2}{R} - mg$$

$$v_c = \sqrt{Rg}$$

New topics (do not read this slide)

SHM, stable equilibrium, restoring force, oscillations, small oscillations, Hooke's law, Newton's 2nd law for SHM, simple harmonic motion (SHM), SHM for horizontal spring, analogy between SHM and UCM, motion equation for SHM,S, V, A graphs for SHM, period, frequency, angular frequency, amplitude, elastic potential energy, energy graphs, conservation of energy, SHM for a vertical spring, a simple pendulum, SHM for a simple pendulum, a physical pendulum; fluids, density, pressure, pressure in a static fluid, atmospheric pressure, gauge pressure, absolute pressure, the Pascal's law, the buoyant force, Archimedes' principle, A static equilibrium for objects in liquid, solving buoyancy problems, fluid dynamics, an ideal fluid, streamline flow, an incompressible fluid, mass flow rate, volume flow rate, the continuity equation, the Bernoulli's equation, solving fluid dynamics problems.

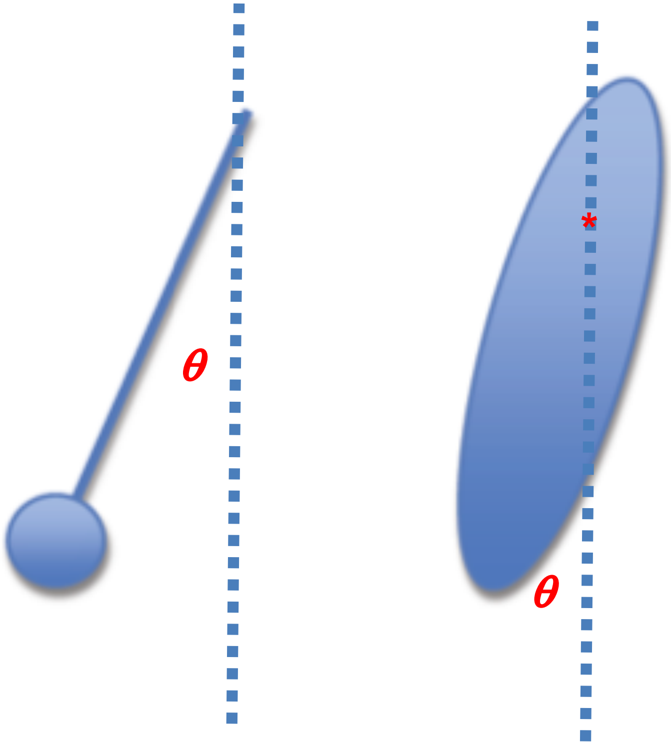
HW3P1 recommended deadline = 6/22 11 pm
actual deadline = 6/28 11 pm

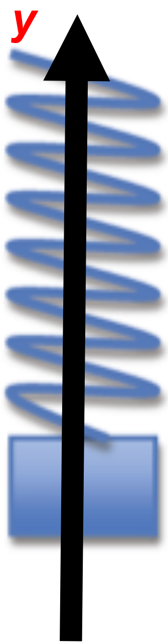
HW3P2 recommended deadline = 6/24 11 pm
actual deadline = 6/28 11 pm

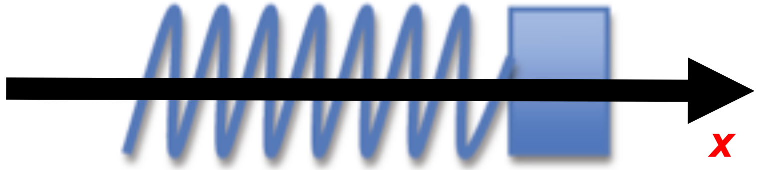
HW3P3 recommended deadline = 6/26 11 pm
actual deadline = 6/28 11 pm

HW3P4 recommended deadline = 6/27 11 pm
actual deadline = 6/28 11 pm

Oscillations !! → When the motion repeats itself!







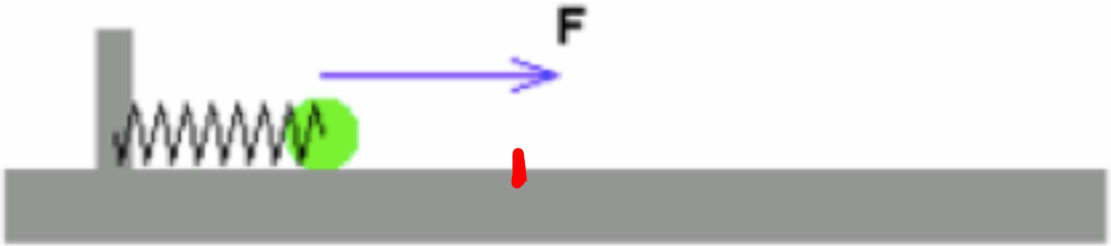
a.k.a. a ***stable*** equilibrium

Always choose the origin at the equilibrium position !!!!

Restoring force always points at the equilibrium position !!!!

In the picture below you see a snapshot of a ball attached to a spring with *the force acting at that instant from the spring on the ball*. *The location of the stable equilibrium of the ball is …*

1. To the left to the ball.
2. At the location of the ball.
3. To the right to the ball.
4. Destroyed.
5. Stolen
6. All of the above



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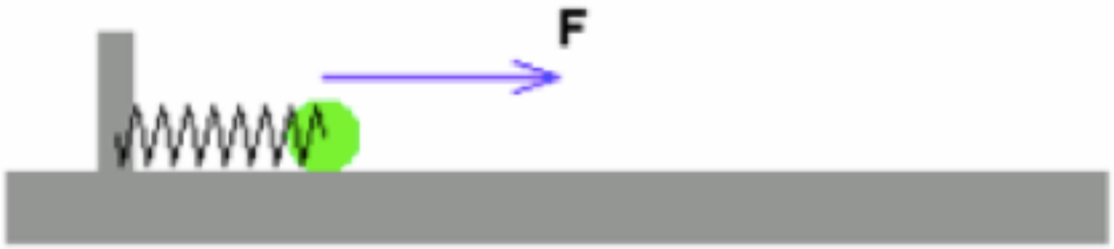
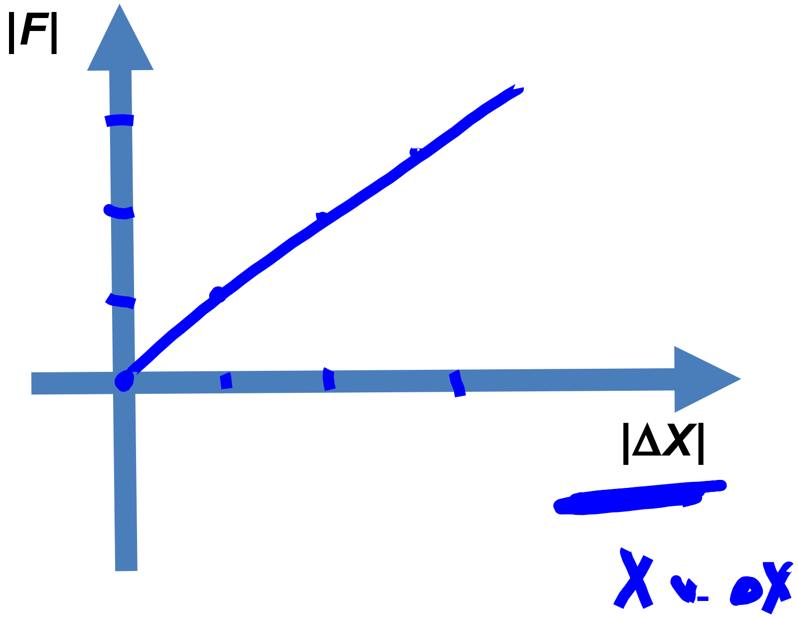


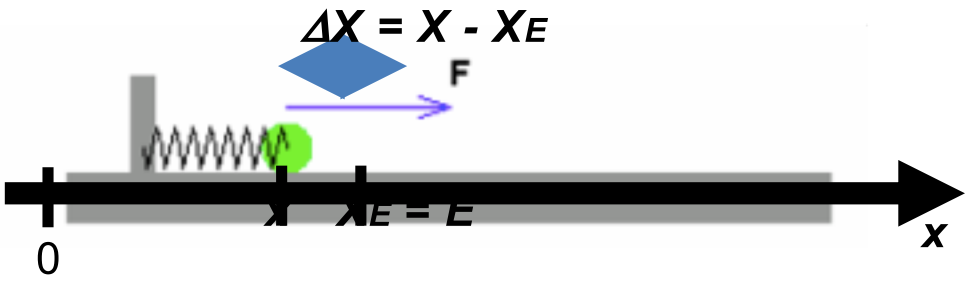
Investigating elastic force

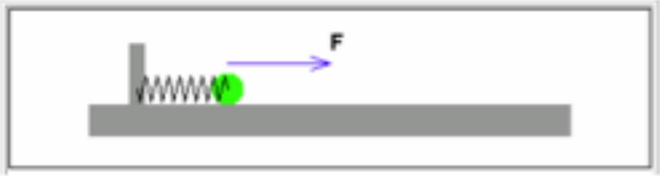


$\|\Delta X\|$	$\|F\|$

$y = m \cdot x + b$

$|F| = k \cdot \Delta X + \cancel{b}$





Springs

So far we've dealt mostly with constant forces.

Springs are more complicated - not only does the magnitude of the spring force vary, the direction of the force depends on whether the spring is being stretched or compressed.

Measuring all distances from the equilibrium length of the spring, the force from an ideal spring is given by Hooke's Law:

$$|\mathbf{F}| = k|\Delta\mathbf{x}| \quad \text{or} \quad k = \frac{|F|}{|\Delta x|}$$

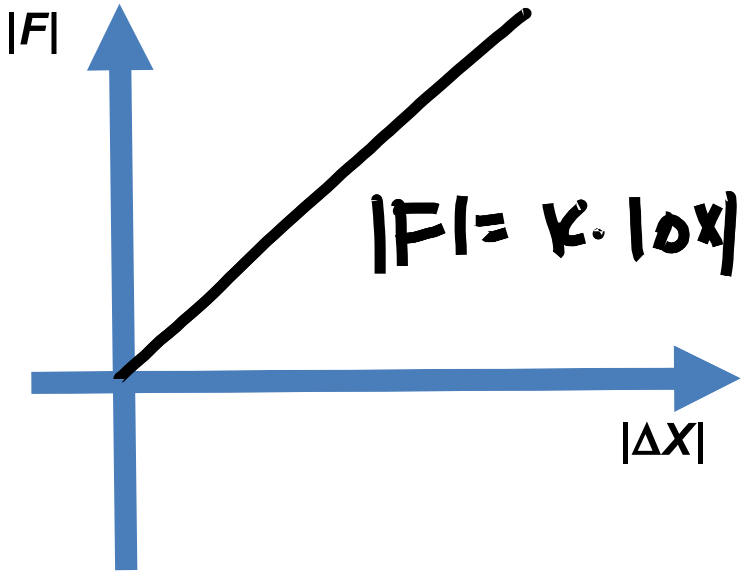
k is the spring constant, a measure of the stiffness of the spring (N/m).

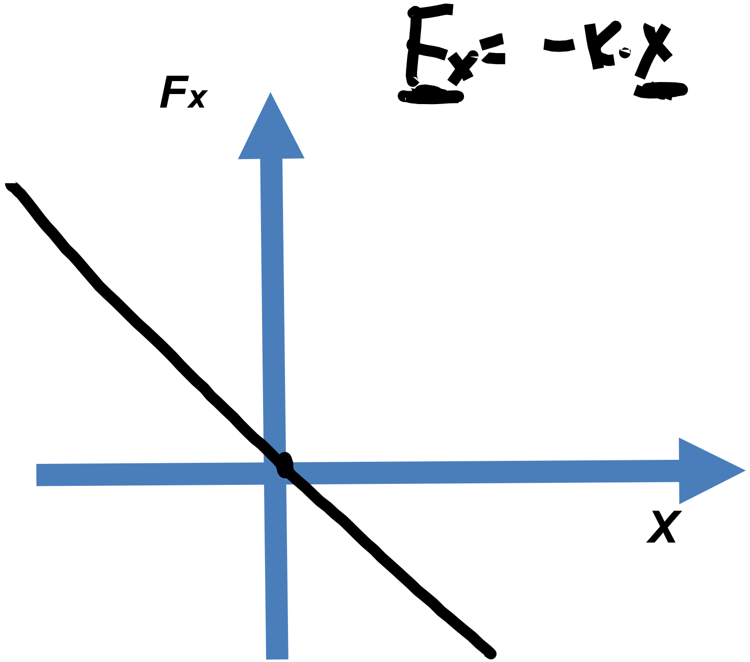
$|\mathbf{F}|$ is the absolute value of the elastic force

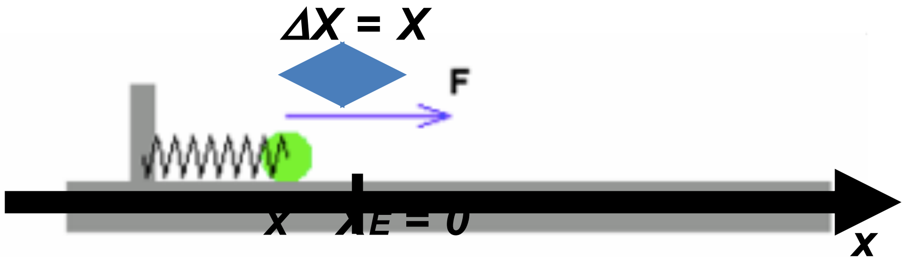
$|\Delta\mathbf{x}|$ is the absolute value of the displacement from the equilibrium position.

The spring force is *always* opposite to the direction to the displacement!!

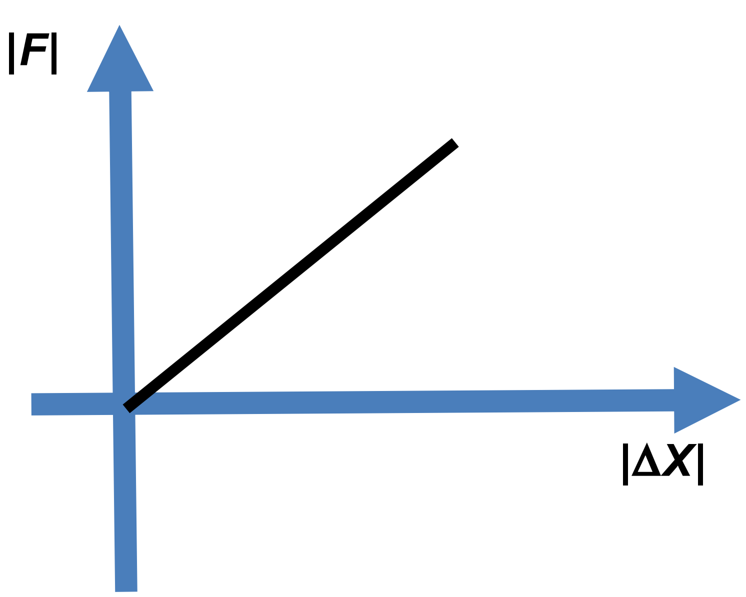
Investigating elastic force

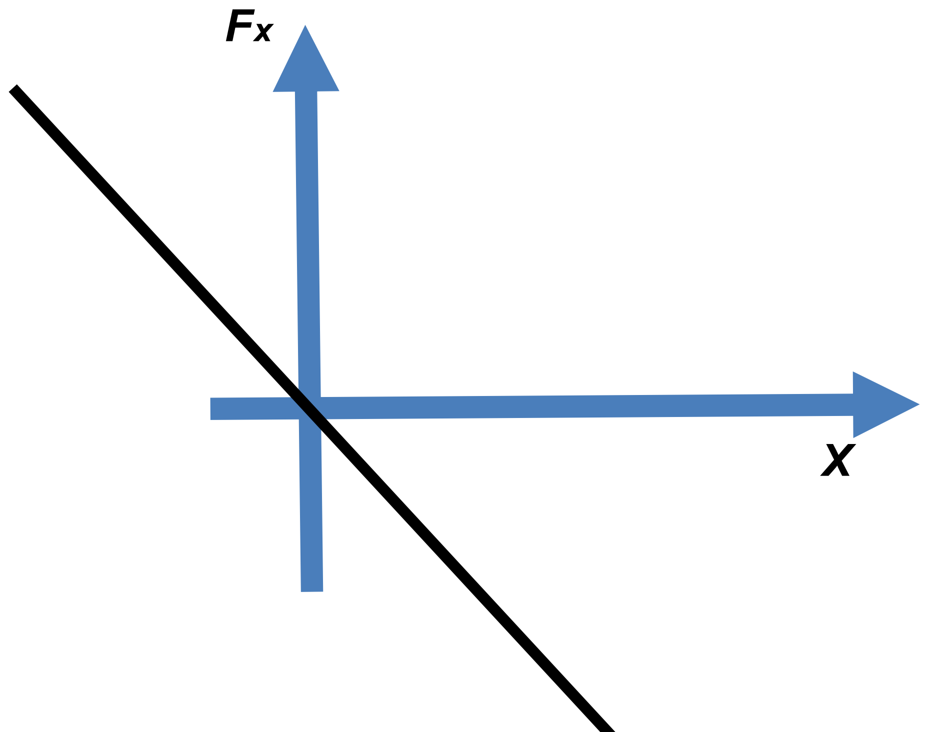






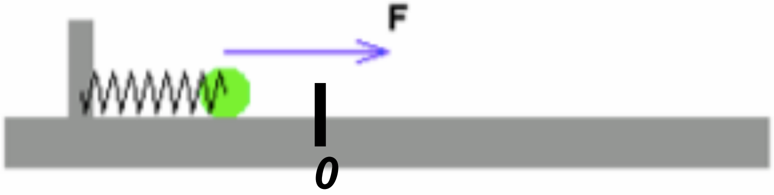
Set the equilibrium location to $X = 0$ to make $\Delta X = X$ (when possible) !





$$|\mathbf{F}| = k|\Delta \mathbf{x}|$$

$$F_X = -kx$$



Hint: Set the origin at the equilibrium position; $\Delta x = x - 0 = x$

We attach a 100 g weight to a vertical spring and the spring stretches *by* 10 cm.

Spring/force constant k = …

1. 10 N/m
2. 20 N/m
3. 30 N/m
4. Etc.

$$|\mathbf{F}| = k|\Delta \mathbf{x}|$$

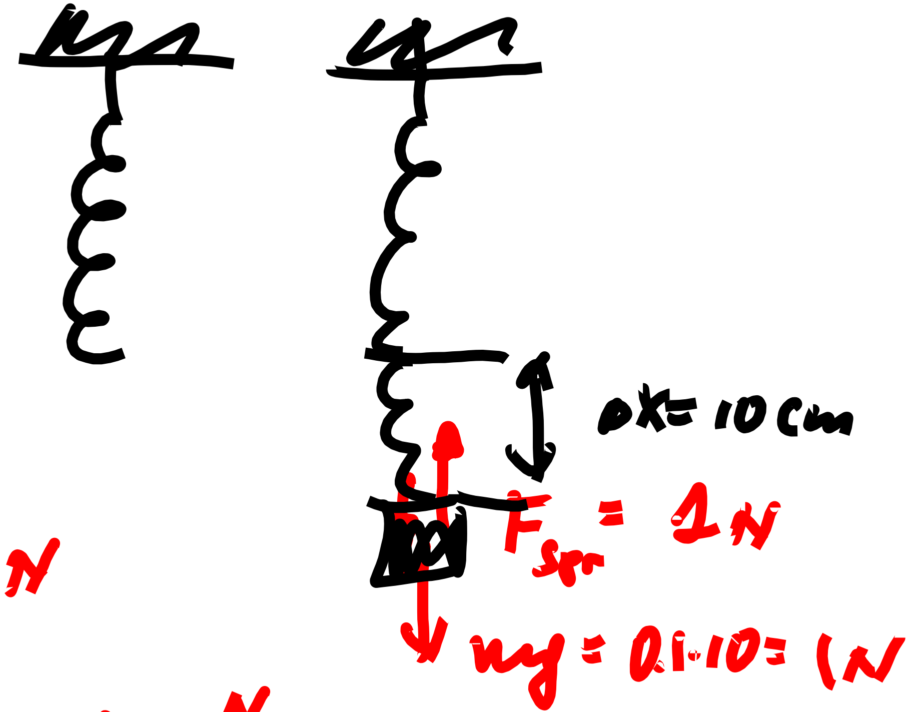
$$F_x = -kx$$

We attach a 100 g weight to a vertical spring and the spring stretches *by* 10 cm

$k = \dots$

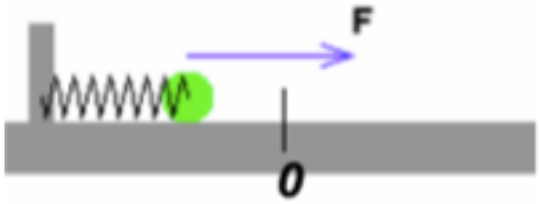
1. 10 N/m
2. 20 N/m
3. 30 N/m
4. Etc.

$$|\mathbf{F}| = k|\Delta \mathbf{x}| \qquad F_x = -kx$$

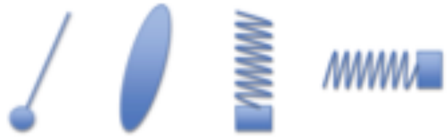


$F_d = 1\,N$

$$k = \frac{|F|}{|\Delta x|} = \frac{1\,N}{.1\,m} = 10\,\frac{N}{m}$$

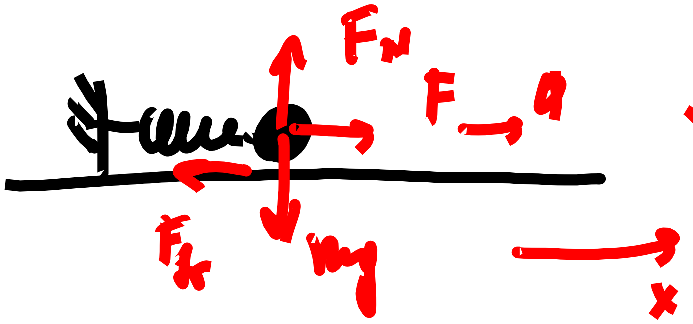


Dynamics of SHM



N2L

Eq



x: $F - F_{fr} = m \cdot a$; $\underline{F_{fr} = 0}$

y: $F_N - mg = 0$

$$\underline{-k \cdot x = m \cdot a_x}$$

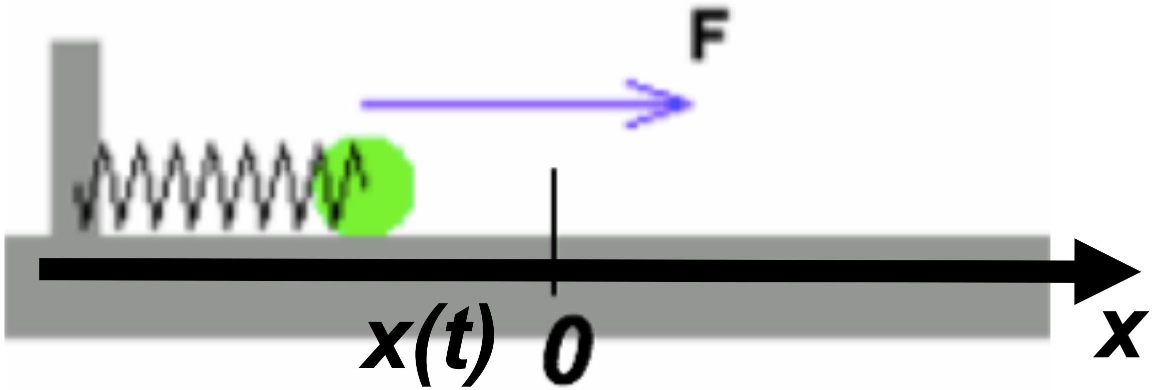
When $F \to 0$

$\underline{\Delta x = x}$

$$\underline{a_x = -\frac{k}{m} \cdot x}$$ $\frac{k}{m} = \text{const} > 0$

$$\underline{a_x = -\omega^2 \cdot x}$$ $\frac{k}{m} = \omega^2$

Dynamics of SHM



Hooke's law;
setting the origin
at the equilibrium

N2L

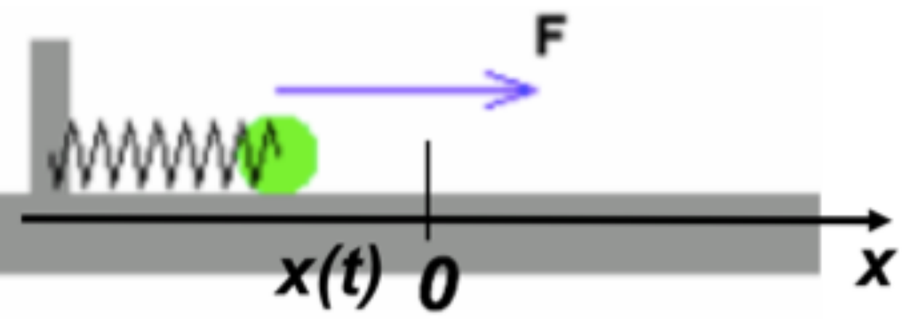
$ma_x = F_x$

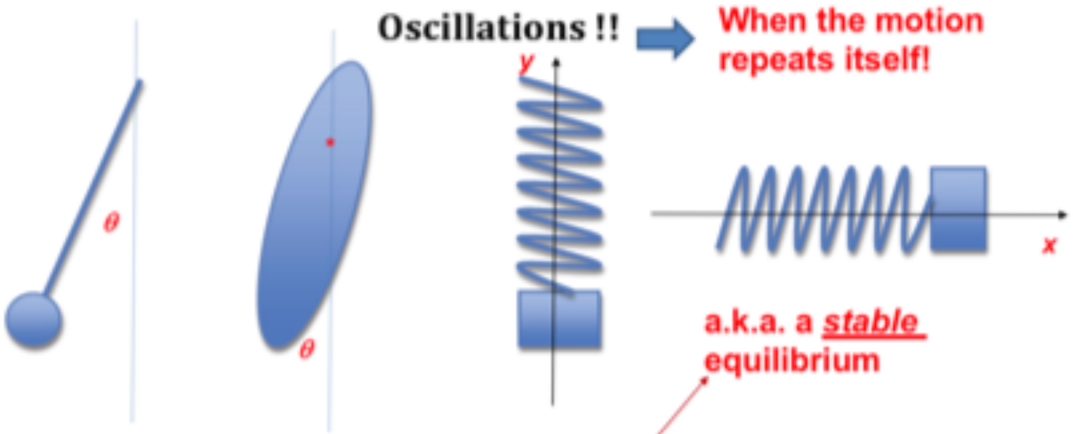
$F_x = -kx$

$ma_x = -kx$

$$a_x = -\frac{k}{m}x \qquad \boxed{\frac{k}{m} = \omega^2} \qquad \boxed{a_x = -\omega^2 x} \qquad \frac{a_x}{x} = -\omega^2$$

Dynamics of SHM





Always choose the origin at the equilibrium position !!!!

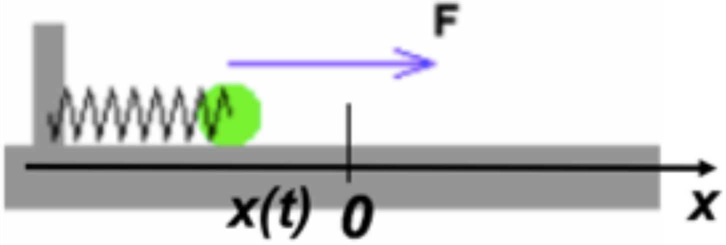
Restoring force always points at the equilibrium position !!!!

For an object on a spring

$$\boxed{\frac{k}{m} = \omega^2}$$

For ANY SHM

$$\boxed{a_x = -\omega^2 x}$$



Dynamics of SHM

Hooke's law and setting the origin at the equilibrium

N2L

$ma_x = F_x$

$F_x = -kx$

$ma_x = -kx$

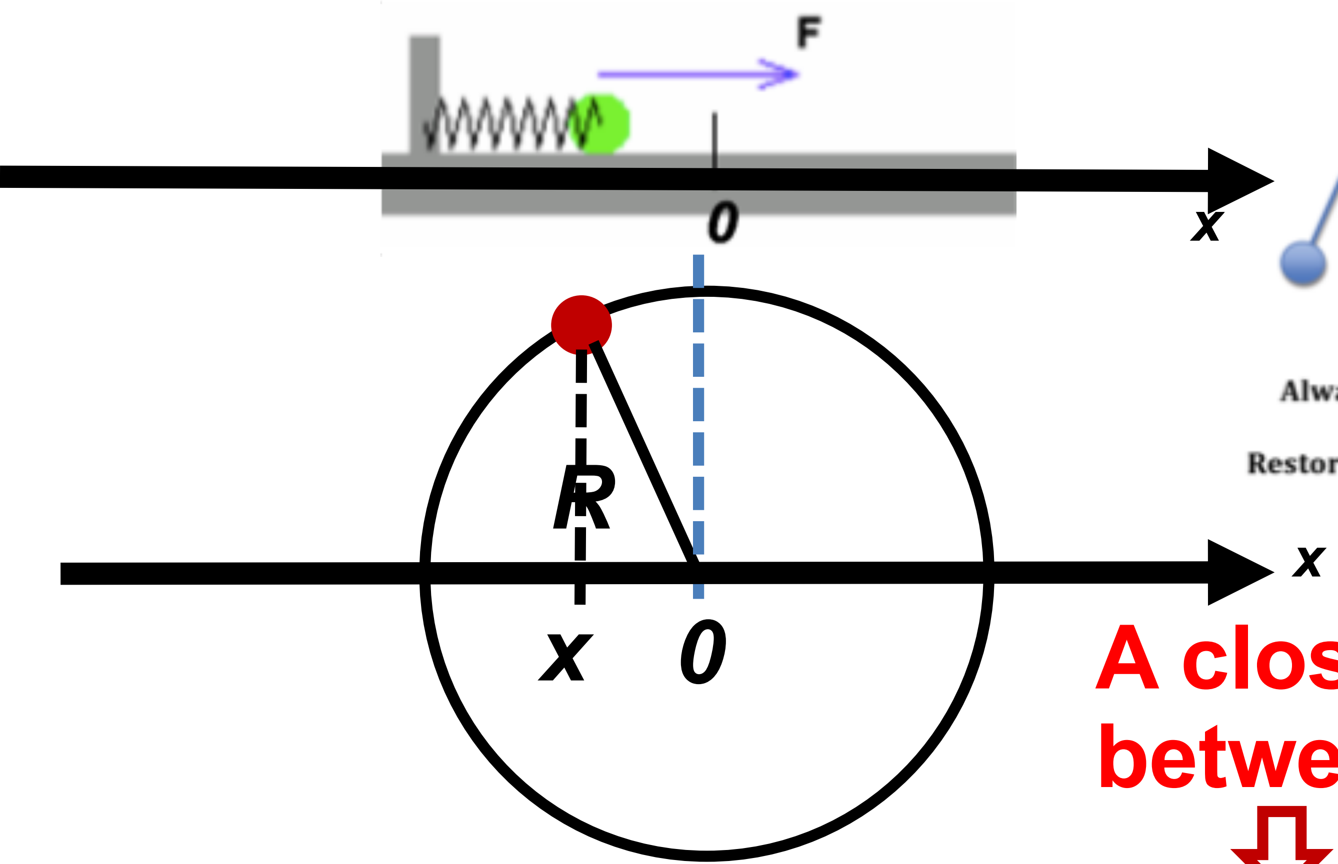
$$a_x = -\frac{k}{m}x \qquad \frac{k}{m} = \omega^2$$

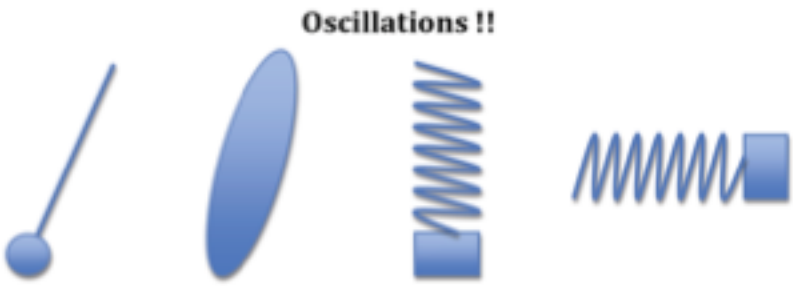
$$\boxed{a_x = -\omega^2 x}$$

$$\frac{\Delta\left(\frac{\Delta x}{\Delta t}\right)}{\Delta t} = -\omega^2 x$$

Way too complicated!

Simple Harmonic Motion v. Rotational Motion



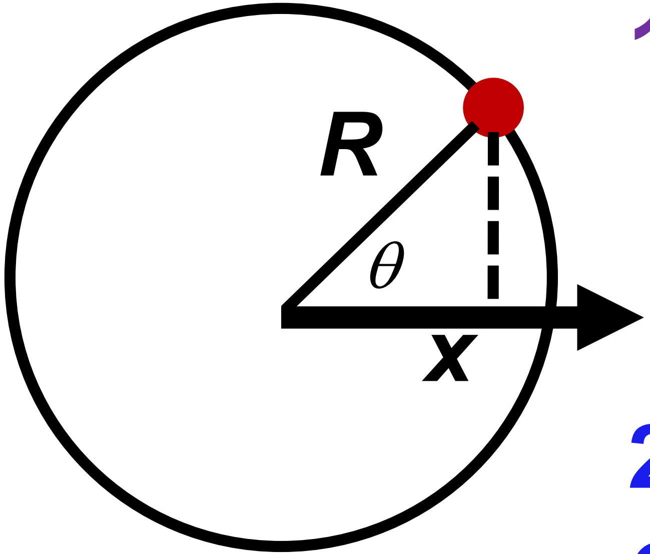


Always choose the origin at the equilibrium position !!!!

Restoring force always points at the equilibrium position !!!!

A close analogy between SHM and RM:

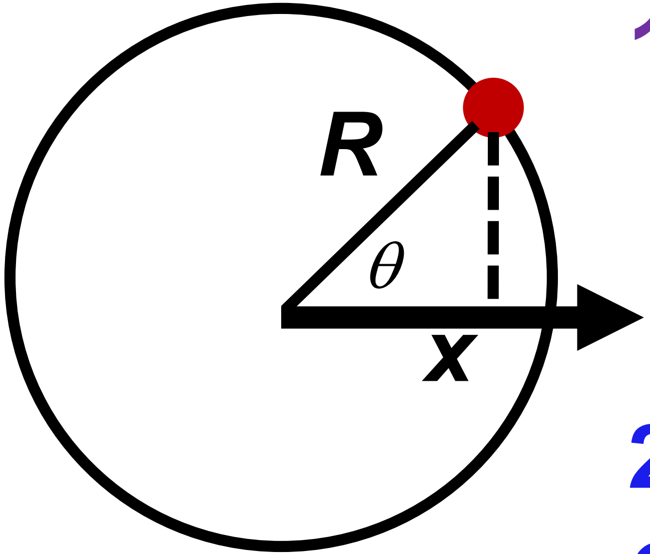
the same x - coordinate!



1. What is the relationship between R, X, and θ?

2. For a circular motion with ***constant*** angular velocity, ω, what is the relationship between θ, ω, and t?

1. $\theta = 4$
2. $\theta = \theta_0 + \omega t$
3. $\theta = \theta_0 + \omega t + \alpha t^2/2$
4. $\theta = \theta_0 + \omega t + \alpha t^3/3$
5. *None of the above*
6. *What is θ?*
7. *Why is the ball red?*



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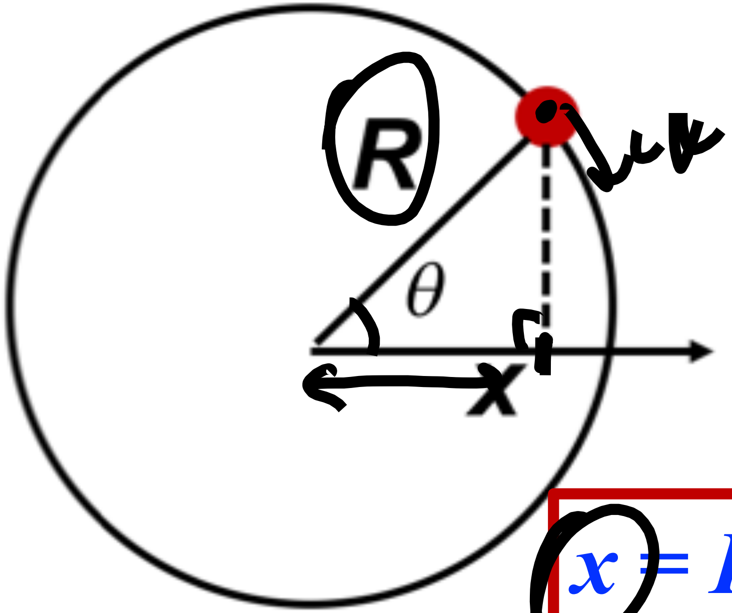
SHM v. Rotational Motion



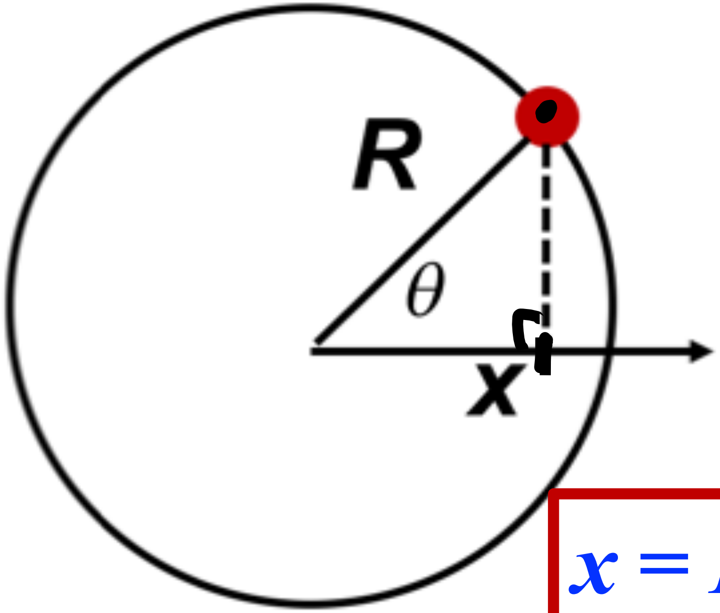
1. $x = R * \cos\theta$

2. $\theta = \theta_0 + \omega t$

SHM equation

$$\boxed{x = R * \cos(\theta_0 + \omega t)}$$

SHM v. Rotational Motion



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SHM equation

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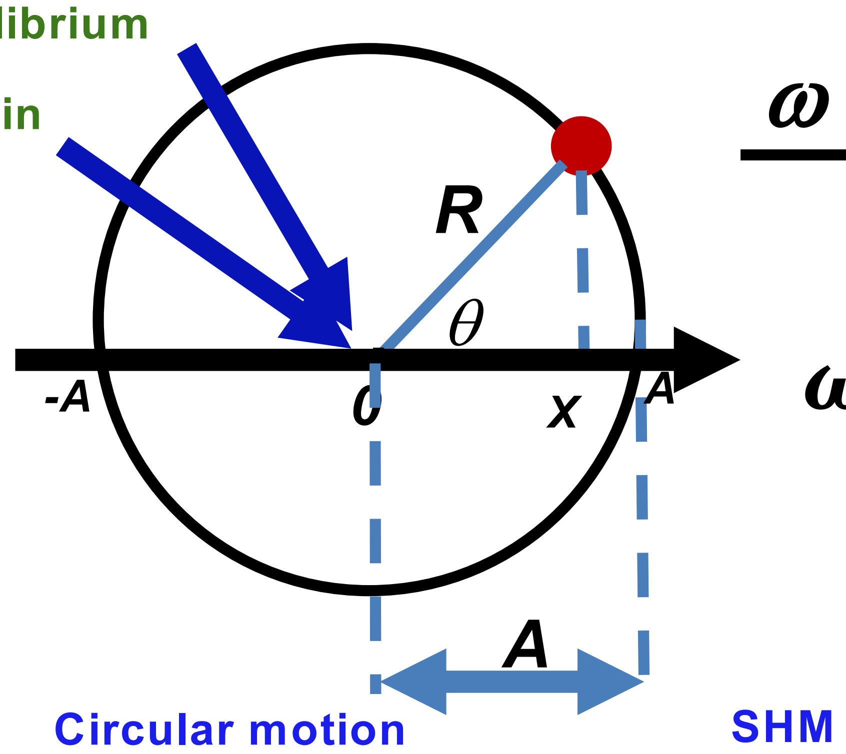
SHM v. Rotational Motion

For rotational motion ← $R = A$ → For oscillations



$$\omega = \text{const}$$

$$\theta = \theta_0 + \omega t$$

$$\omega = \frac{v}{R} = \frac{(2\pi R/T)}{R} = \frac{2\pi}{T} = 2\pi f$$

$$\boxed{\omega = \frac{2\pi}{T} = 2\pi f}$$

$$X = R\cos(\theta) = A\cos(\omega t + \theta_0)$$ ⇐ "Our" motion equation