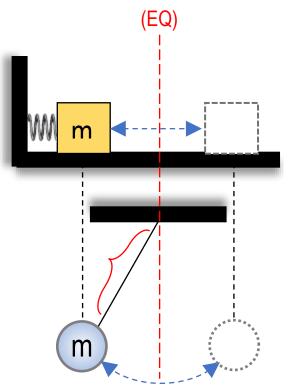
CONCEPT: Simple Pendulums

● Just like mass-spring systems, pendulums also display Simple Harmonic Motion.

Mass-Spring

Pendulum



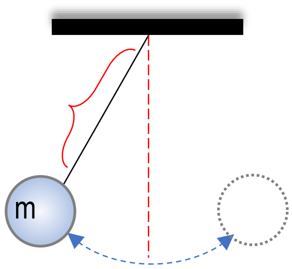
F = ______ a = ______	$\omega = 2\pi f = \frac{2\pi}{T} =$ ______
F = ______ ≈ ______ a = ______ ≈ ______	$\omega = 2\pi f = \frac{2\pi}{T} =$ ______

- Make sure θ and calculator is in RADIANS.

● For SHM, restoring force must be proportional to deformation/distance.

- For small angles, _______ ≈ _______. → Restoring Force: __________

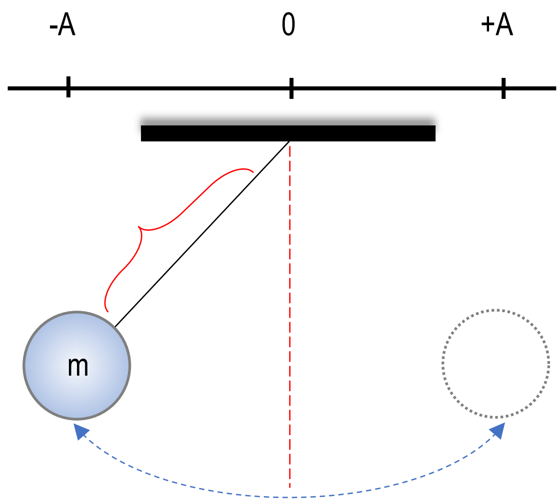
Example 1: You pull a 0.250m long pendulum with a hanging mass of 4kg to the side by 3.50° and release. Find the (**a**) restoring force, (**b**) period of oscillation, (**c**) time it takes for the mass to reach its maximum speed.



EXAMPLE: After landing on an unfamiliar planet, an astronaut constructs a simple pendulum of length 3m and mass 4kg. The astronaut releases the pendulum from 10 degrees with the vertical, and clocks one full cycle at 2s. Calculate the acceleration due to gravity at the surface of this planet.

Pendulum SHM Equations
$\lvert F_R \rvert = -mg\theta$ $a = -g\theta = -\frac{g}{L}x$
$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{g}{L}}$ $N\ [\text{cycles}] = \frac{t\ [\text{time}]}{T\ [\text{Period}]} = t * f$

CONCEPT: Pendulum SHM Equations



Mass-Springs	Pendulums
x = deformation from EQ	At <u>any</u> point: x = ________ ≈ ________
x_{max} = A v_{max} = Aω a_{max} = Aω^2	x_{max} = ________ = ________ v_{max} = Aω = ____________ a_{max} = Aω^2 = ____________
$\omega = 2\pi f = 2\pi/T = \sqrt{\frac{k}{m}}$	$\omega = 2\pi f = 2\pi/T = \sqrt{\frac{g}{L}}$

- If asked for θ given t ⟶ $\theta(t) = \theta_{max} cos(\omega t)$

<u>EXAMPLE</u>: A 500-g mass hangs from a 40-cm-long string. The object has a speed of 0.25m/s as it passes through its lowest point. What maximum angle (in degrees) does the pendulum reach?

EXAMPLE**:** A 100g mass on a 1.0m-long string is pulled 7.0° to one side and released**.** How long does it take to reach 4.0° on the opposite side?

Pendulum SHM Equations
$\lvert F_S \rvert = \lvert F_A \rvert = -mg\theta$ $a = -g\theta = -\frac{g}{L}x$
$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{g}{L}}$ $N\,[\text{cycles}] = \frac{t\,[\text{time}]}{T\,[\text{Period}]} = t * f$
$\theta(t) = \theta_{max}\cos(\omega t)$ → $x_{max} = A = L\theta$ → $v_{max} = A\omega = L\theta_{max}\omega$ → $a_{max} = A\omega^2 = L\theta_{max}\omega^2$
→ $a_{max} = A\omega^2 = L\theta_{max}\omega^2$