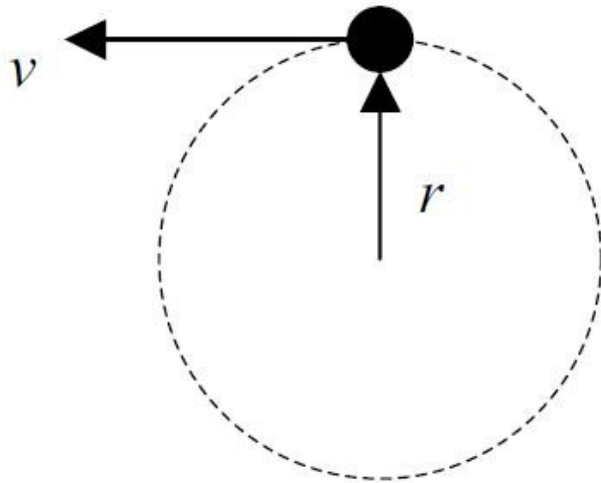


Types of Forces

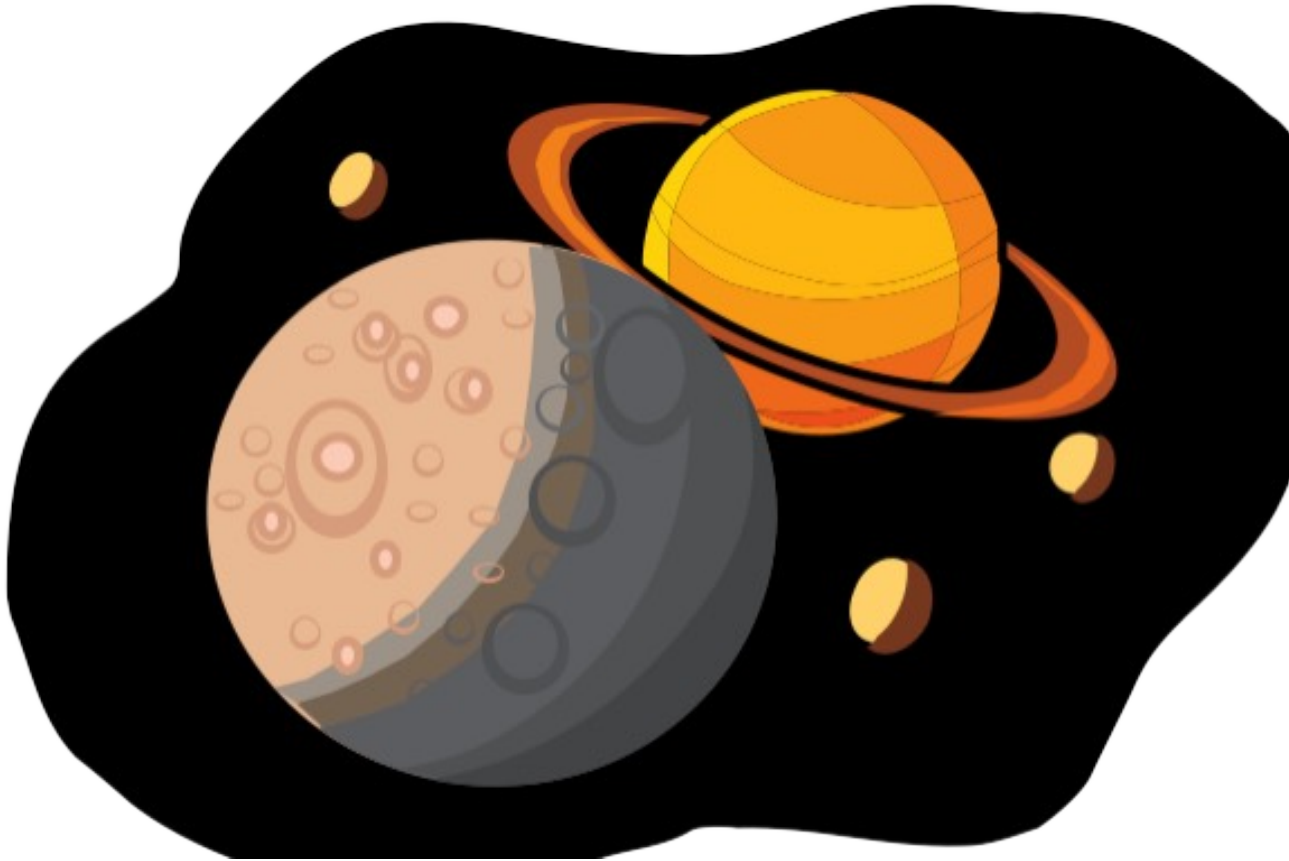
■ Centripetal Force



$$F = \frac{mv^2}{r}$$

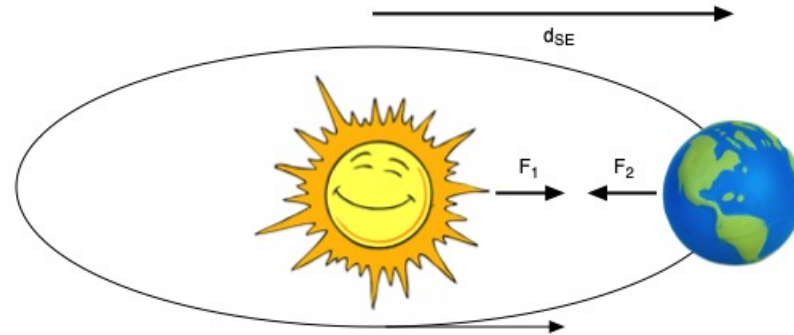
Types of Forces

- **Gravitational Force**



Types of Forces

■ Gravitational Force



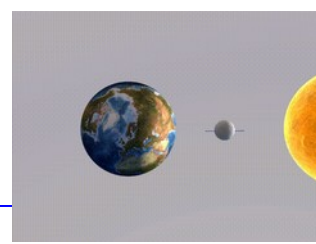
$$F = F_1 = F_2 = \frac{M_s \cdot M_E}{d_{sE}^2} = 3.5 \times 10^{22} \text{ N}$$

$$\vec{F} = G \frac{M_1 M_2}{|\vec{R}_{12}|^3} \vec{R}_{12} = M_2 g$$

$$G = 6.674 \cdot 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$$

$$g = 6.674 \cdot 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2} \frac{5.9736 \cdot 10^{24} \text{ kg}}{(6,375 \cdot 10^6 \text{ m})^2} = 9.81 \frac{\text{N}}{\text{kg}}$$

Types of Forces



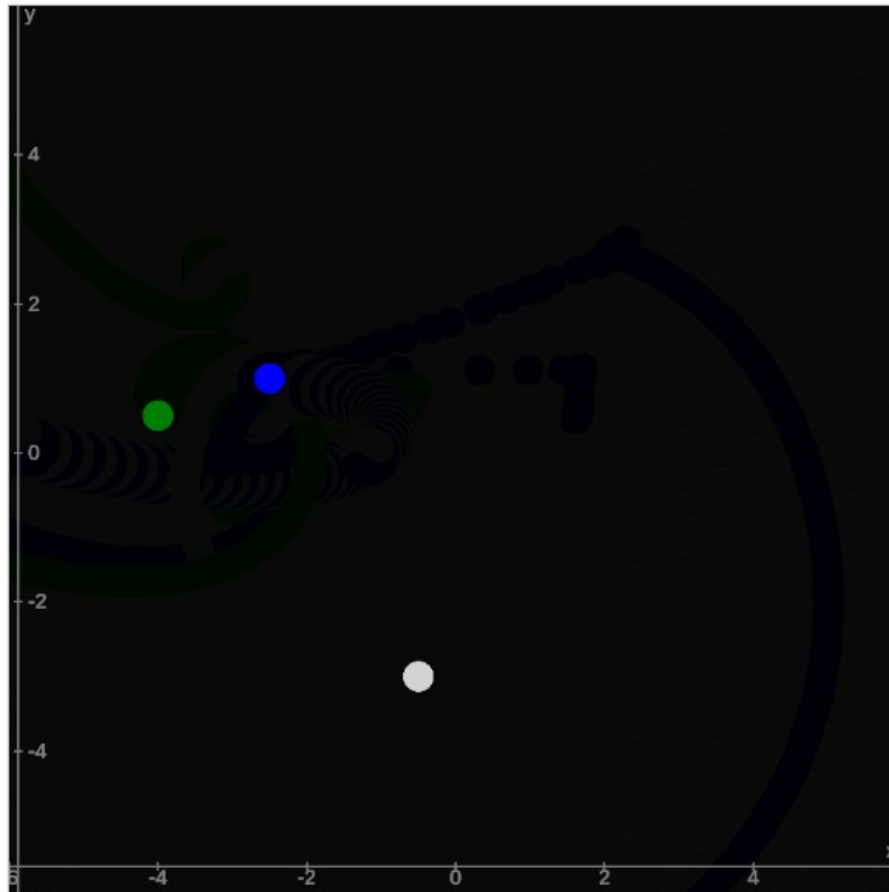
■ Gravitational Force

Mutual Attraction

myPhysicsLab.com

English [previous](#) [next](#)

Sim Graph Time Graph Multi Graph



number of bodies

gravity

damping

elasticity

show forces

show energy

show clock

pan-zoom

time step

time rate

Diff Eq Solver

potential energy offset

background

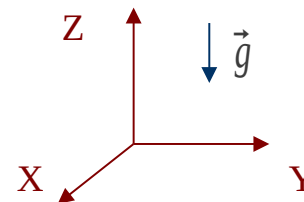
terminal

<https://www.myphysicslab.com/engine2D/mutual-attract-en.html>



Gravitation Force

■ Equations of motion for projections

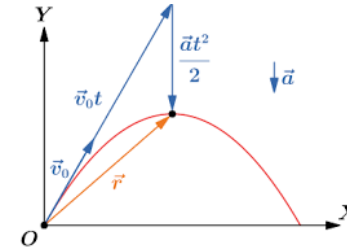


Quantity	Differential Equation	Solution
Acceleration	None	$a_z = -g,$ $a_x = 0, \quad a_y = 0$
Velocity	$\frac{dv_z}{dt} = a_z = -g$	$v_z = v_{z0} - gt,$ $v_x = v_{x0}, \quad v_y = v_{y0}$
Location	$\frac{d^2 z}{dt^2} = a_z = -g$ $\frac{dz}{dt} = v_z = v_{z0} - gt$	$z = z_o + v_{z0}t - \frac{1}{2}gt^2,$ $x = x_o + v_{x0}t,$ $y = y_o + v_{y0}t$



Gravitation Force

Equations of motion in vector form



Quantity

Differential Equation

Solution

Acceleration

None

$$\vec{a} = \vec{g}$$

Velocity

$$\frac{d\vec{v}}{dt} = \vec{a} = \vec{g}$$

$$\vec{v} = \vec{v}_o + \vec{g}t$$

Location

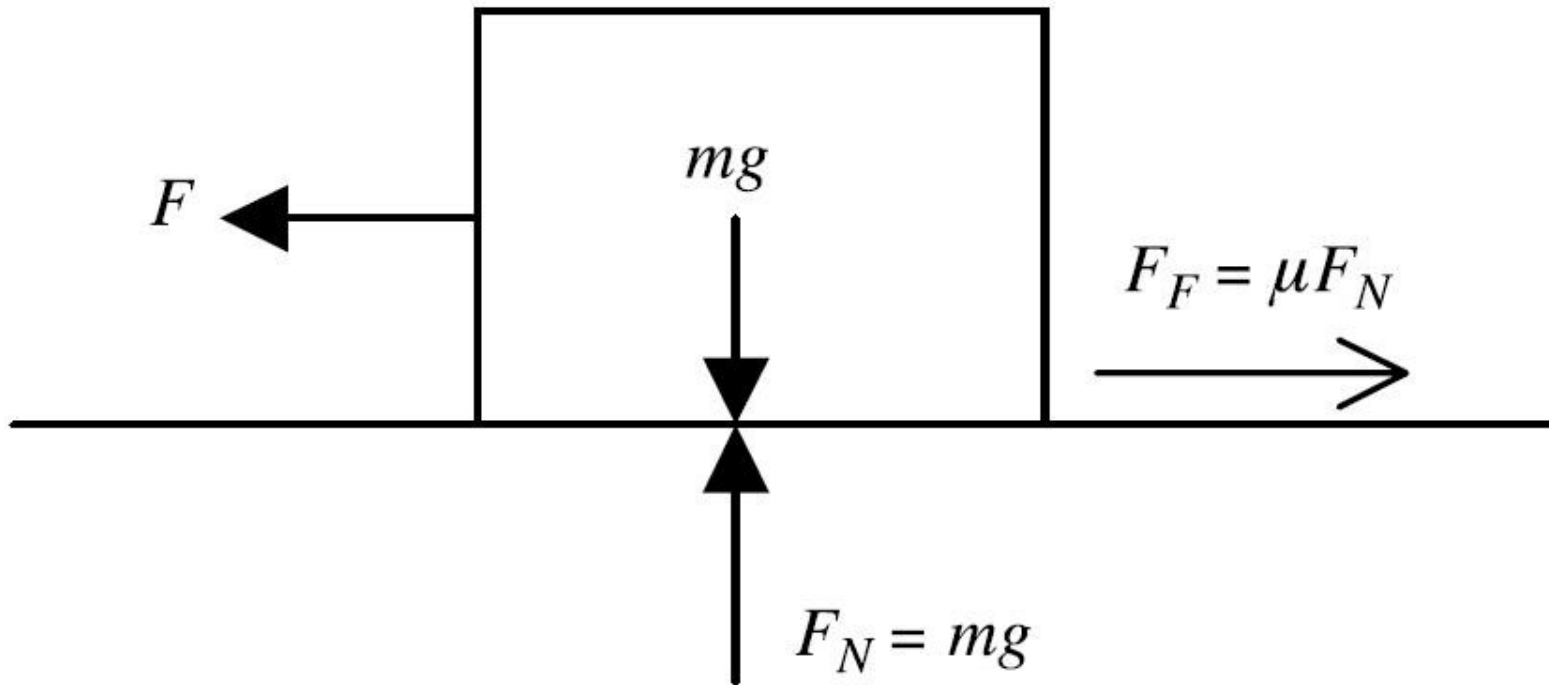
$$\frac{d^2\vec{r}}{dt^2} = \vec{a} = \vec{g}$$

$$\frac{d\vec{r}}{dt} = \vec{v} = \vec{v}_o + \vec{g}t$$

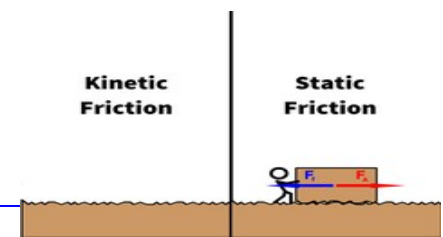
$$\vec{r} = \vec{r}_o + \vec{v}_o t + \frac{1}{2}\vec{g}t^2$$

Friction

$$F_F = \mu F_N$$



Friction



■ Friction Coefficients for Some Common Surface Interactions

Materials	μ_s	μ_k
Steel—steel	0.7–0.74	0.57–0.6
Steel—steel (lubricated)	0.12	0.07
Aluminum—steel	0.61	0.47
Copper—steel	0.53	0.36
Cast iron—cast iron	1.1	0.15
Teflon—Teflon	0.04	0.04
Glass—glass	0.94	0.4
Wood—wood	0.25–0.5	0.2–0.3
Rubber—concrete	1.0	0.8
Rubber—concrete (wet)	0.7	0.5
Ice—ice	0.1	0.03
Waxed ski—snow	0.1–0.14	0.05–0.1

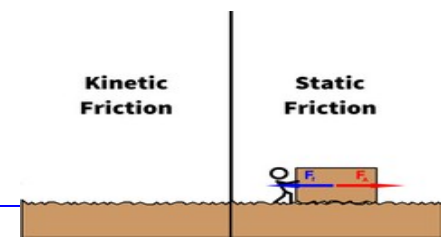
* Source: RoyMech, www.roymech.co.uk

* Raymond Serway and John Jewitt, Physics for Scientists and Engineers, Sixth Edition (Brooks-Cole, 2003)

* www.physlink.com/Reference/FrictionCoefficients.cfm

* Encarta.msn.com

Friction



Bad and good friction

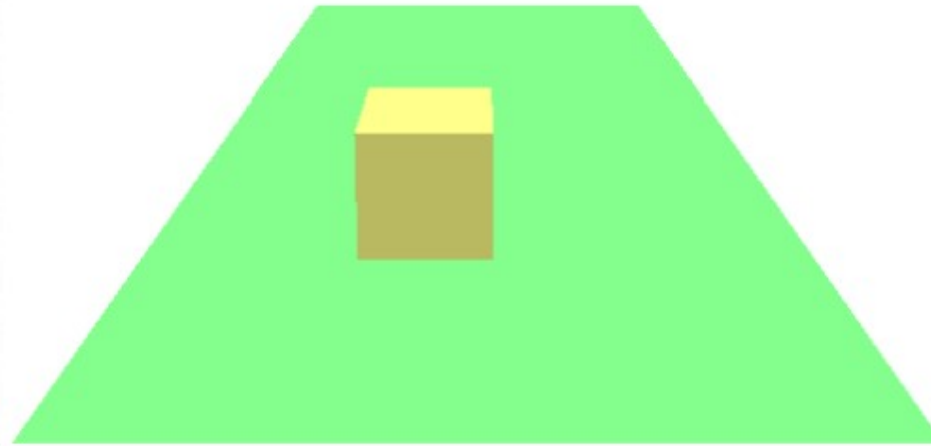
Friction

Starting velocity: 0.916667

Current velocity: 0

Zero crossing check

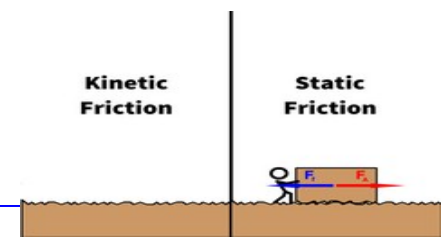
Reset



The sliding block demo

<https://www.computer-graphics.se/demos/files03/Beachball-demos.zip>

Friction



Bad and good friction

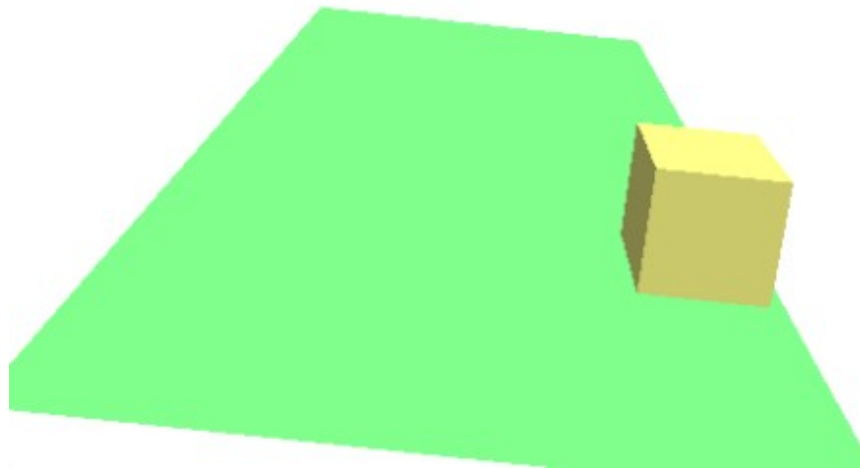
Friction example

Starting velocity: 0.4
Current velocity: 0.0104139

Slope: 0.106356

Zero crossing check
 Low speed check

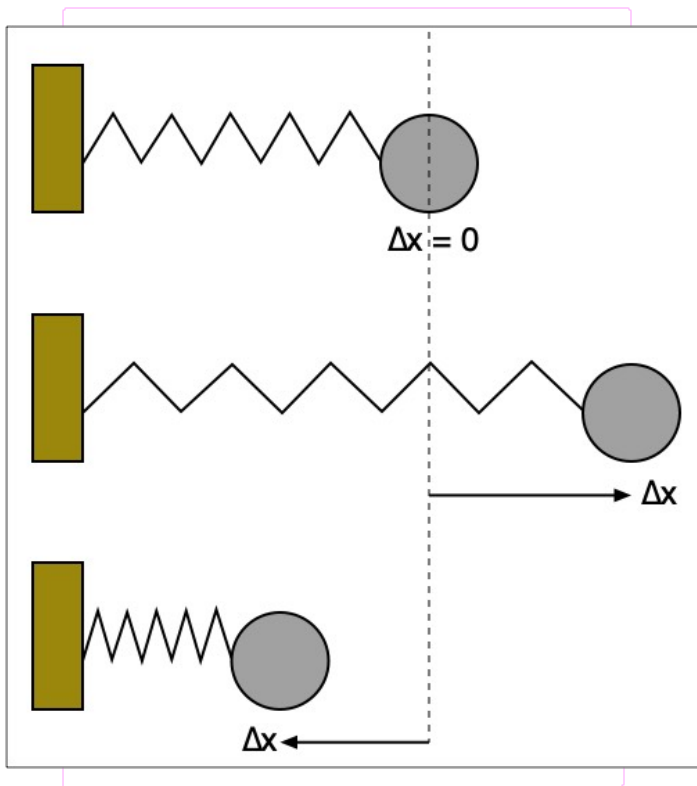
Reset



The sliding block demo 2

Vibration

■ Deformation Springs



Hooke's Law

$$\vec{F} = -k\Delta\vec{x}$$

Equation of motion: $m\ddot{x} = -kx$

$$\ddot{x} + \omega^2 x = 0 \quad \omega^2 = \frac{k}{m}$$

Solution: $x(t) = A \sin(\omega t + \phi_0)$

$$T = \frac{2\pi}{\omega} = 2\pi \sqrt{\frac{m}{k}}$$

Vibration

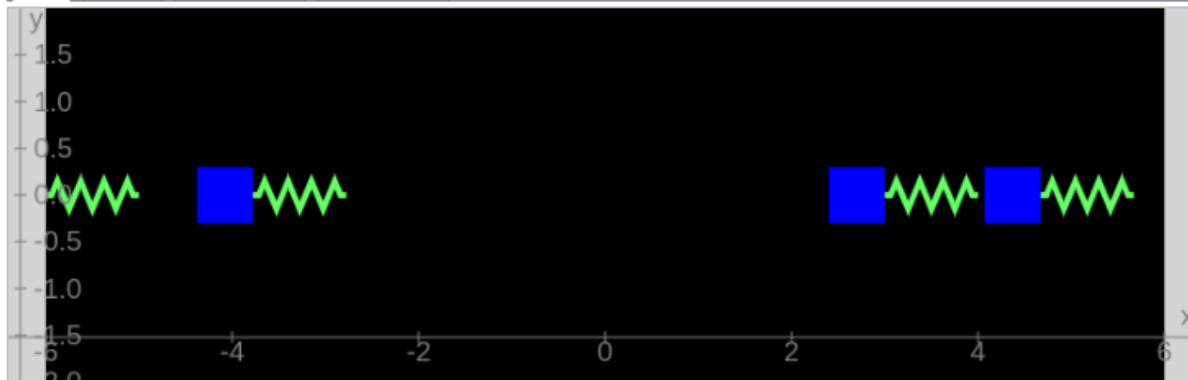
■ Deformation Springs

Collide Springs

myPhysicsLab.com

Sim Graph Time Graph Multi Graph

English previous next



number blocks 3

start position

starting gap

damping 0.00

spring damping 0.00

mass 0.100

spring length 1.00

terminal

spring stiffness 60.0

show energy

show clock

pan-zoom

time step

time rate

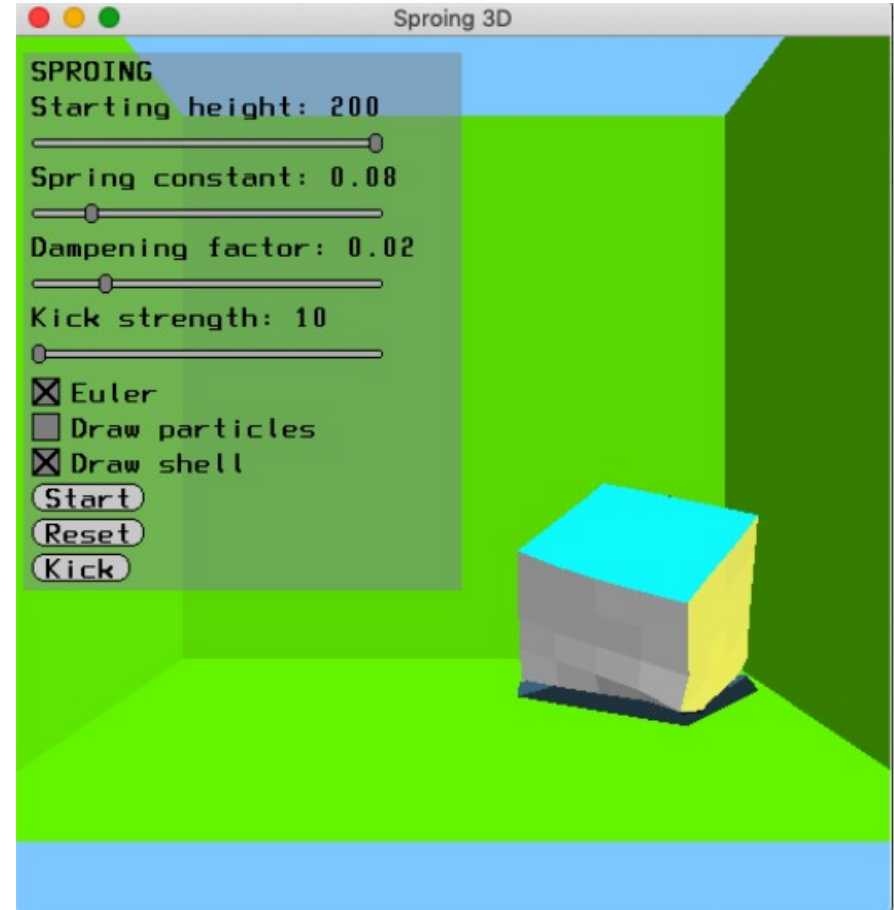
Diff Eq Solver

background

<https://www.mypysicslab.com/springs/collide-spring-en.html>

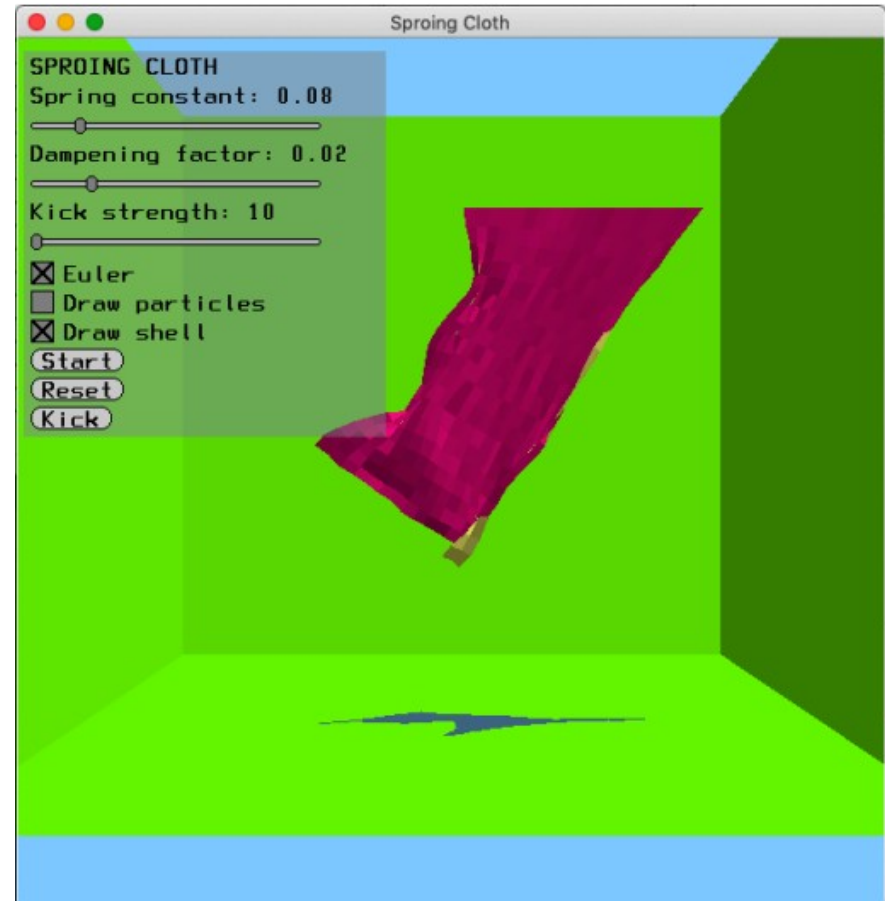
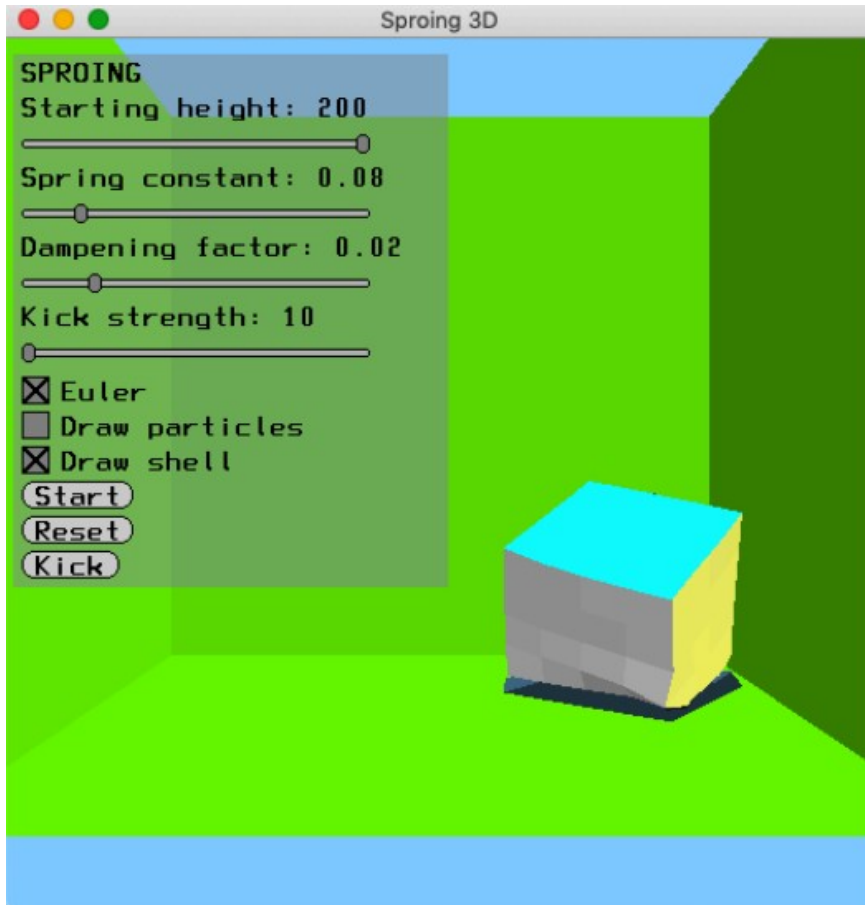
Vibration

■ Deformation



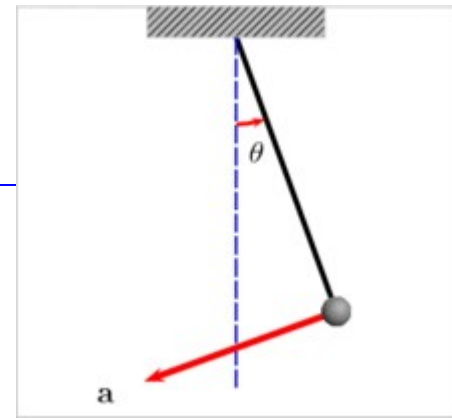
Vibration

■ Deformation



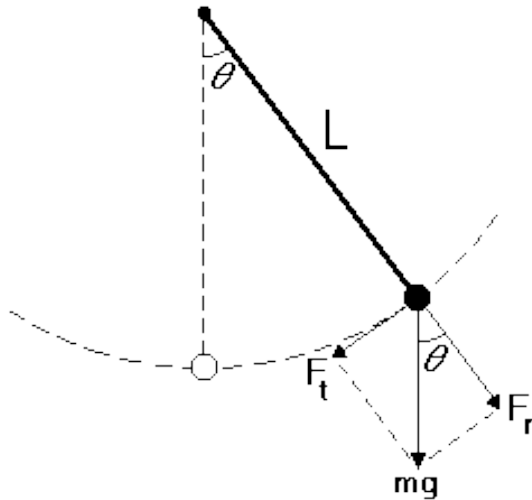
Vibration

■ Pendulum



$$\vec{F} = -mg \sin \theta = -\frac{mg}{L} \Delta \vec{x}$$

$$\vec{F} = -k \Delta \vec{x}$$



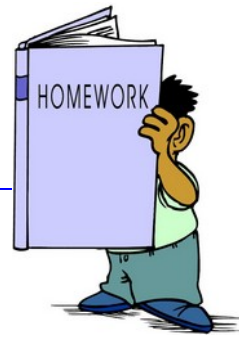
Equation of motion: $m \ddot{x} = -kx$

$$\ddot{x} + \omega^2 x = 0 \quad \omega^2 = \frac{g}{L}$$

Solution: $x(t) = A \sin(\omega t + \phi_0)$

$$T = \frac{2\pi}{\omega} = 2\pi \sqrt{\frac{L}{g}}$$

Vibration



■ Boat



Write the equation of motion for a boat in water.

What is the period of the vibration?