Forces

IB Physics Content Guide

Big Ideas

- Many forces acting on an object can be simplified down into one net force
- For objects in equilibrium, all the forces cancel out for a net force of 0 N
- The magnitude of some forces depends on other forces (i.e. friction depends on normal force)

1 – Equilibrium

I can define a force (with proper units) in terms of the interaction between two objects			
I can calculate the resultant vector for 2 vectors in one dimension or at right angles			
I can calculate the net force on an object			
I can calculate an unknown force for an object in equilibrium			
I can describe Newton's first law			

2 – Types of Forces

I can calculate the weight of an object			
I can describe the difference between mass and weight			
I can use a diagram to identify the direction of tension and normal forces			
I can draw a free body diagram with weight, normal force, friction, and any other forces			
I can describe how the stretch of a spring and its elastic force are related by a spring constant			
I can calculate spring constant through an equation or Force vs Distance graph			
I can explain how the direction of an elastic force is related to the deflection of the spring			

3 – Friction and Ramps

I can calculate the force of friction when given the normal force and coefficient of friction			
I can quantitatively compare surfaces based on their coefficients of friction			
I can describe how the normal force is impacted by an inclined surface			
I can calculate parallel and perpendicular components of the force due to gravity on a ramp			
I can calculate the force of friction required to keep an object in equilibrium on a ramp			

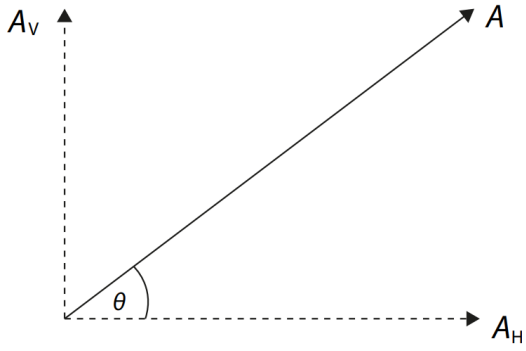
4 – Buoyant Force

I can describe and calculate an object's density when related to mass and volume			
I can determine the amount of liquid displaced by an object placed into a container			
I can calculate the buoyant force on an object placed surrounded by a fluid of known density			
I can predict whether an object will float or sink based on the buoyant force and weight			
I can analyze situations where objects are floating when only partially submerged			
I can find the forces (tension or normal) required to keep a submerged object in equilibrium			

Name of Force	Variable	Description/Important Properties	Equation
Weight	F_g	Force of gravity on an object with mass (always downward)	$F_g = mg$
Tension	F_T	Always pulls in the same direction as the rope or chain providing the tension	
Normal	F_N	Force of a surface pushing on an object. (always perpendicular to the surface)	
Elastic	F_H	Restoring force proportional to and in opposite direction a spring's displacement	$F_H = -kx$
Friction	F_f	Sliding contact force that opposes the motion of an object	$F_f = \mu F_N$
Buoyant	F_b	Force on submerged object (always upward)	$F_b = \rho Vg$

Geometry Review

Vectors



$A_H = Acos\theta$
$A_V = Asin\theta$
${A_H}^2 + {A_V}^2 = A^2$

Volume

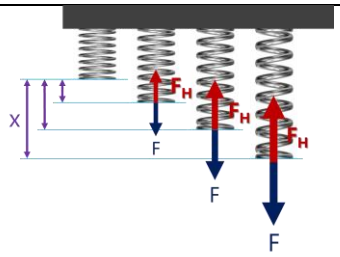
Volume of a cuboid	$V = lwh$ where l is the length, w is the width, h is the height
Volume of a cylinder	$V = \pi r^2 h$
Volume of a prism	$V = Ah$ where A is the area of cross-section
Volume of a sphere	$V = \frac{4}{3}\pi r^3$

Weight

	Variable Symbol	Description	Unit
$F_g = mg$	F_g	Weight	Newtons [N]
	m	Mass	Kilograms [kg]
	g	Gravitational Field Strength	9.8 N/m (on Earth)

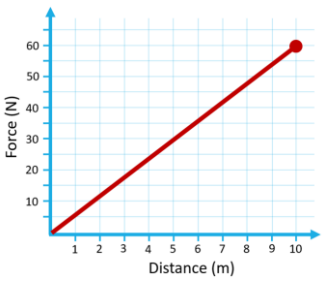
Elastic Force

	Variable Symbol	Description	Unit
$F_H = -kx$	F_H	Elastic Force	Newtons [N]
	k	Spring Constant	Newtons per meter [N/m]
	x	Spring Stretch	Meters [m]



Calculate k (with units) from graph

$$Slope = \frac{60}{10} = 6\frac{N}{m}$$



What does the negative mean?

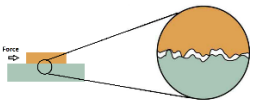
$$F_H = -kx$$

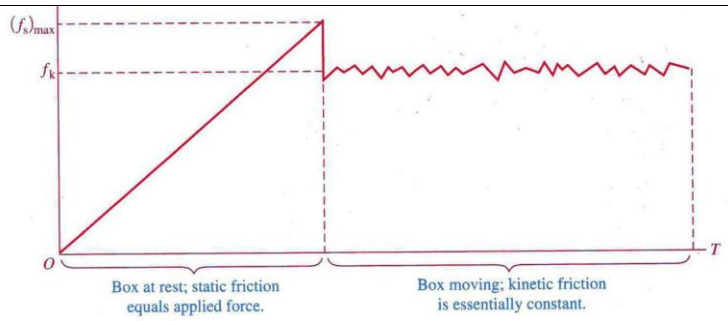
Force is in the opposite direction of deflection

Friction

	Variable Symbol	Description	Unit
$F_f \leq \mu_s F_N$ $F_f = \mu_d F_N$	F_f	Force of Friction	Newtons [N]
	μ_s	Coefficient of static friction	*unitless*
	μ_d	Coefficient of dynamic friction	*unitless*
	F_N	Normal Force	Newtons [N]

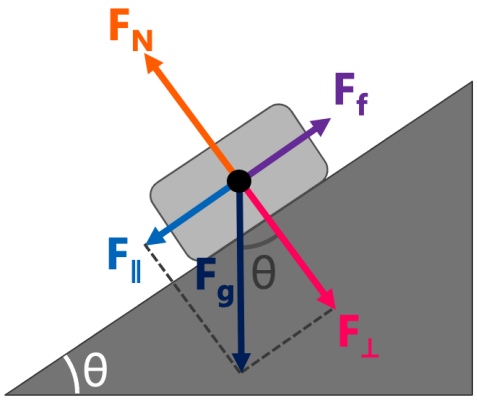
Static Friction	Dynamic Friction
• Not moving • Hard to get started	• In motion (sliding) • Lower than static





Ramps

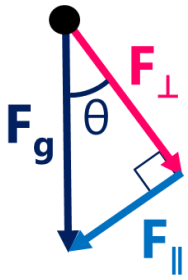
Label me:



$F_g = mg$

$F_{||} = F_g \sin\theta$

$F_\perp = F_g \cos\theta$



$F_N = F_\perp$

$F_f = F_{||}$* *in equilibrium

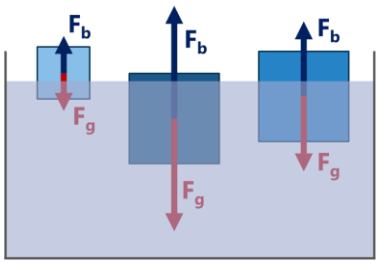
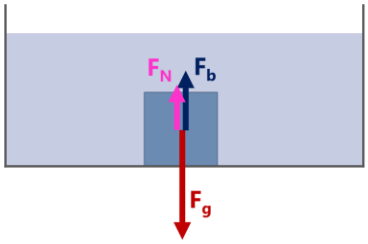
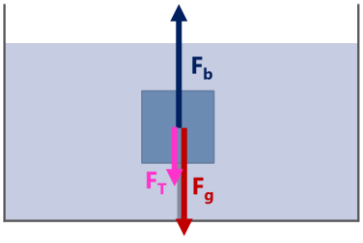
Buoyant Force

$$\rho = \frac{m}{V}$$

Variable Symbol	Description	Unit
ρ	Density	[kg/m^3]
m	Object mass	[kg]
V	Object Volume	[m^3]

$$F_b = \rho V g$$

Variable Symbol	Description	Unit
F_b	Buoyant Force	Newtons [N]
ρ	Fluid Density	[kg/m^3]
V	Displaced Volume	[m^3]
g	Gravitational Field Strength	9.8 N/m

Floating	Resting on Bottom	Tethered to Bottom
		
$F_b = F_g$	$F_N + F_b = F_g$	$F_b = F_T + F_g$