Forces

IB Physics Content Guide

Big Ideas

- Many forces acting on an object can be simplified down into one net force
- Acceleration is zero when net force is zero (could mean stopped or constant velocity)
- If you have the acceleration of an object, you can find the net force causing that acceleration and vice versa
- Force of friction is related to the normal reaction force
- For objects on a sloped surface, the weight must be broken down into its perpendicular and parallel component

Content Objectives

1 – Newton's First Law and Free Body Diagrams

I can define a force (with proper units) in terms of the interaction between two objects			
I can describe Newton's first law			
I can calculate the net force on an object			
I can calculate an unknown force for an object in equilibrium			

2 – Newton's Second Law

I can describe Newton's second law in terms of momentum			
I can calculate force given mass and acceleration and calculate acceleration given force and mass			
I can combine Newton's second law with the kinematic equations to solve force/motion problems			
I can explain the connection between constant velocity and balanced forces			

3 – Weight, Normal Reaction, and Tension

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 reaction forces			
I can draw a free body diagram with weight, normal reaction force, friction, and any other forces			

4 – Calculating Friction

I can calculate the force of friction when given the reaction force and coefficient of friction			
I can quantitatively compare surfaces based on their coefficients of friction			
I can calculate the acceleration of an object with friction based on the external force and mass			

5 – Air Resistance

I can describe the factors that affect air resistance and how the resistance changes with velocity			
I can define Terminal Velocity in terms of net force			
I can graph the change in position and velocity for an object falling with air resistance			

6 – Forces on a Ramp

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			
I can calculate the acceleration of an object with known mass on a ramp of known angle and friction			
I can calculate parallel and perpendicular components of the force due to gravity on a ramp			

Forces

Shelving Guide

Name of Force	Variable	Description/Important Properties	Equation
Weight	F_g	Force of gravity on an object with mass	$F_g = mg$
Tension	F_T	Always pulls in the same direction as the rope or chain providing the tension	
Normal Reaction	R	Always perpendicular to a surface	
Friction	F_f	Always opposes the motion of an object	$F_f = \mu R$
Air Resistance	F_{air}	Increases with surface area and velocity	

If an object has a net force of zero its motion is either:

Not moving (velocity = $0\ m\ s^{-1}$)	or	Moving at a constant velocity

Newton's Laws

Newton's First Law	An object at rest remains at rest and an object in motion remains in motion until and unless an external force acts upon it (Unbalanced force).
Newton's Second Law	The rate of change of momentum of an object is proportional to the resultant force acting on the body and is in the same direction. ($F = ma$)
Newton's Third Law	All forces occur in pairs. Every action has an equal and opposite reaction

	Variable Symbol	Unit
Force	F	N
Mass	m	kg
Acceleration	a	$m\ s^{-1}$
Normal Reaction Force	R	N
Coefficient of Kinetic Friction	μ_d	--
Coefficient of Static Friction	μ_s	--

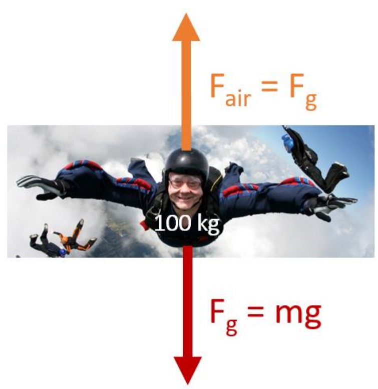
Data Booklet Equations:

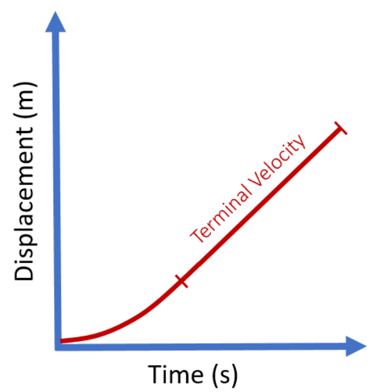
$$F = ma$$

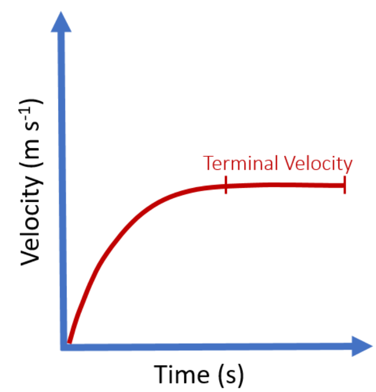
$$F_f \leq \mu_s R$$

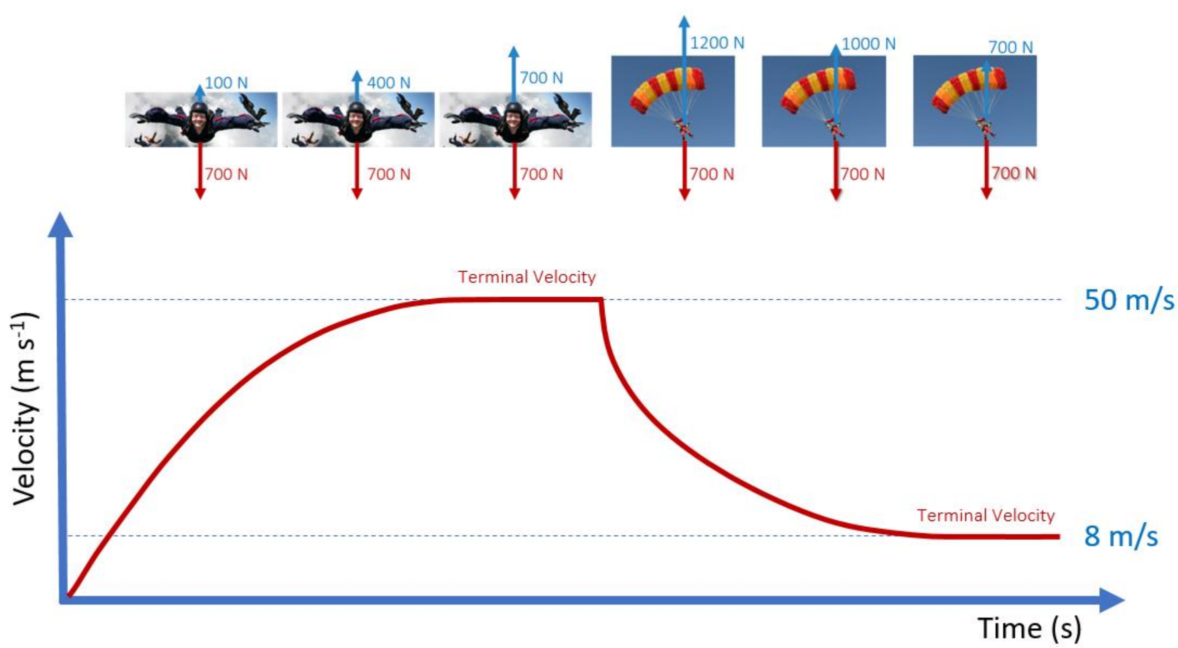
$$F_f = \mu_d R$$

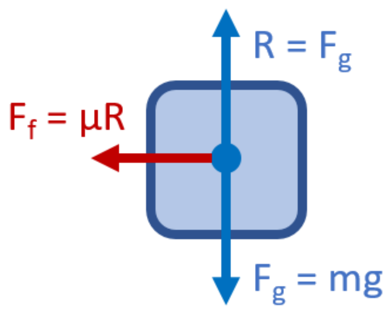
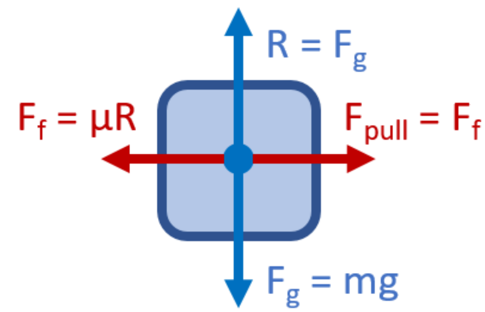
Terminal Velocity	The maximum velocity a falling body can achieve. This occurs when the force of air resistance is equal and opposite to the weight and F_{net} = 0 N.

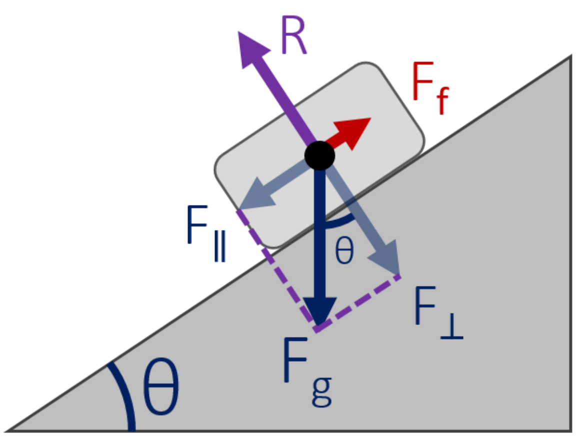








Sliding to a Stop	Constant Velocity	
		
$F_{net} = F_f$	$F_{net} = 0$ N	$F_{pull} = F_f$



$F_\perp$	$F_g \cos\theta$
$F_\parallel$	$F_g \sin\theta$

Forces on a Ramp

Equilibrium	
R	$F_\perp$
F_f	$F_\parallel$
F_{net}	0 N
a	0 m s^{-1}

Accelerating	
R	$F_\perp$
F_f	μR
F_{net}	$F_\parallel - F_f$
a	F_{net} / m