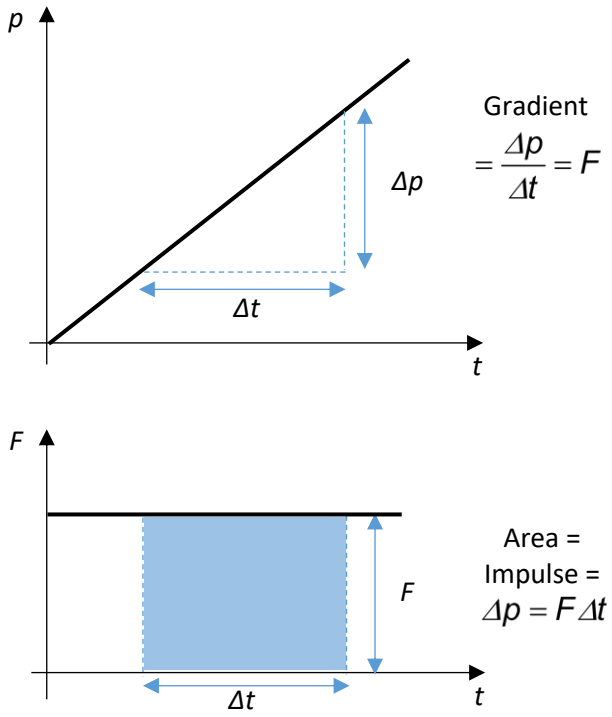
Dynamics

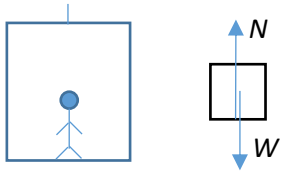
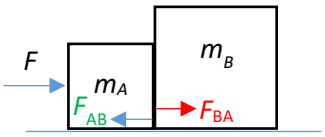
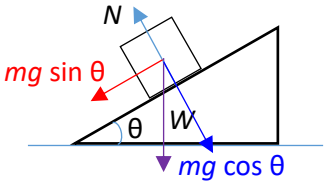
Newton's 1st Law of Motion – A body at rest will remain as rest and a body in motion will continue in motion at constant velocity unless a net force acts on it.

Newton's 2nd Law of Motion – Rate of change of momentum of a body is proportional to the net force acting on it and the direction of momentum change is in the direction of the net force.

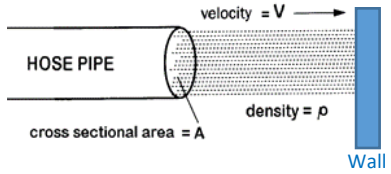
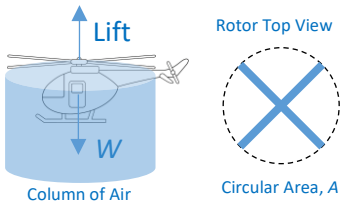
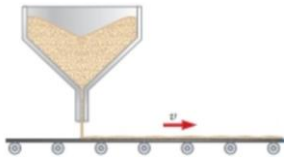
Equations	Graphs
Net force, $\sum F = \frac{dp}{dt}$ As Momentum, $p = mv$, $\sum F = \frac{d(mv)}{dt}$ $\sum F = m\frac{dv}{dt} + v\frac{dm}{dt}$	

Constant *m*	Constant *v*
$\sum F = ma$ • Free Body Diagram • Sum of Forces Equation	$\sum F = v\frac{dm}{dt}$ 1. Flow Rate Problem

Constant *m* problems (Free Body Diagram + Sum of Forces Equation)

Lift	Connected Bodies	Incline Plane
 Equilibrium, $N = W$ $\sum F = N - W = 0$ Accelerate up, $N > W$ $\sum F = N - W = ma$ Accelerate down, $N < W$ $\sum F = N - W = -ma$	 Same acceleration for both $\sum F = F = (m_A + m_B)a$ For object A, $\sum F_A = F - F_{AB} = m_A a$ For object B, $\sum F_B = F_{BA} = m_B a$	 Acceleration along plane, $\sum F = mg\sin\theta = ma$, $N = mg\cos\theta$

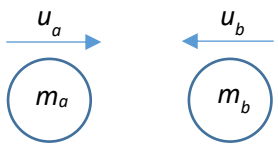
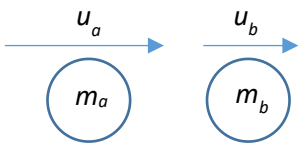
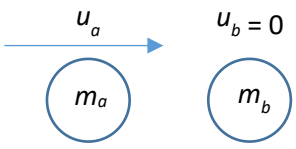
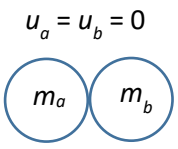
Flow Rate Problems (Free Body Diagram + Sum of Forces Equation)

Water Hose	Helicopter	Mass on moving Belt
		
Impact force on wall: $\sum F = v\frac{dm}{dt}$ $\sum F = v\frac{d(AL\rho g)}{dt} = v.A\rho g\frac{dL}{dt} = v^2 A\rho g$		Force required to move sand, $\sum F = v\frac{dm}{dt}$ $\frac{dm}{dt}$ → Rate of mass falling

Conservation of Linear Momentum – Total sum of momentum is conserved in collision

General Inelastic Collision

Before Collision:

			
*u_b is negative	*u_b is positive	*u_b is zero	*explosion case

By Principle of Conservation of Linear Momentum,

$$m_a u_a + m_b u_b = m_a v_a + m_b v_b$$

Elastic Collision	Perfectly Inelastic Collision
Equation 1: $m_a u_a + m_b u_b = m_a v_a + m_b v_b$ Equation 2: $u_a - u_b = v_b - v_a$ • Sum of kinetic energy is conserved • Relative speed of approach is equal to Relative speed of separation	Equation 1: $m_a u_a + m_b u_b = m_a v_a + m_b v_b$ Equation 2: $v_a = v_b$ • Object stick together after collision

Newton's 3rd Law of Motion – Whenever a force acts on a body, an equal but oppositely directed force of the same kind acts on another body.

Action-Reaction pair forces

1. are equal in magnitude.
2. are opposite in direction
3. act on two different bodies
4. are of the same nature.