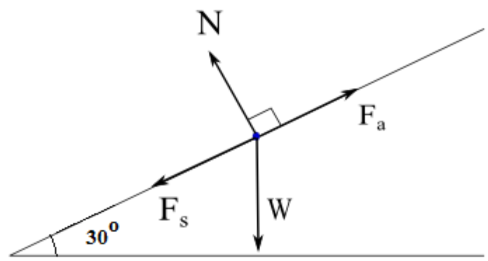
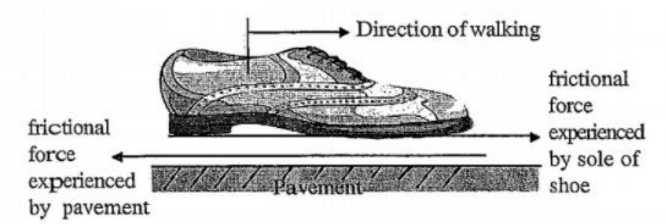
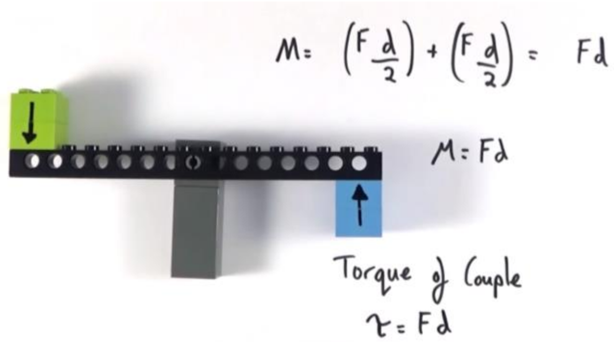
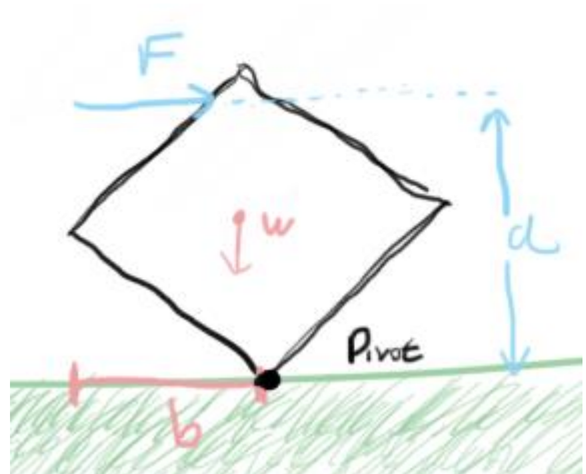
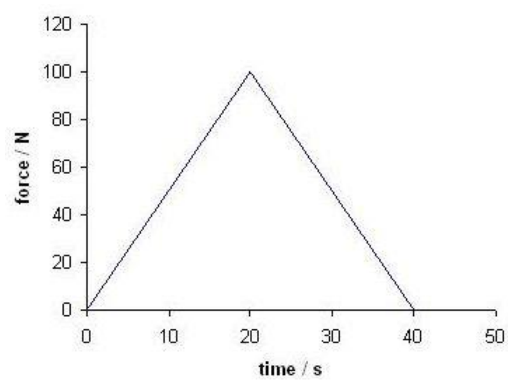
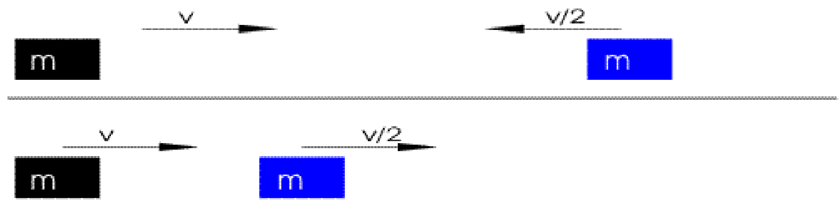
U4 - Mechanics

When is an object in equilibrium?	When there is **NO RESULTANT FORCE** and **MOMENTS BALANCE**. *Thus when ≥ 3 forces act on a body in equilibrium, the resultant of all but one will be **equal and opposite** to the last. Similarly, the sum horizontal and vertical components of all forces is 0.* 
What is Newton's First Law of Motion (Law of Inertia)?	"Every body continues at rest or with a constant **VELOCITY** unless acted upon by a resultant force." *VELOCITY is key as an object moving in a circle experiences a centripetal and is thus accelerating. Let's say you had a cup on a table, although it looks stationary, considering the Earth/Table perspective, it isn't as it's weight is slightly greater than the normal force as it's experiencing a centripetal force due to the Earth's rotation. However, we assume they're the same.*
What is Newton's Second Law of Motion?	"The resultant force is proportional to the rate of change of momentum and **acts in the same direction as the change in momentum.**" $$F = \frac{\Delta(mv)}{\Delta t}$$ *F = ma is a special case of where mass is constant. This cannot be used for a rocket.* *Remember that the change in momentum has to be constant. E.g., going from 5 kgms^{-1} to 0 kgms^{-1} exerts some force whose size is dependent on the time in which this change occurs. Thus cushions work better than harder surfaces such as steel.*

What is Newton's Third Law of Motion?	"For every action, there is an equal and opposite reaction." *This is a result of electrostatic repulsion between electrons. When you "touch" stuff, you're not actually touching it. Your hand is slightly hovering above it.*
What must the forces in Newton's Third Law be?	Of the same type.
Give an example of Newton's Third Law and explain the importance of frictional forces	● By walking, you push the earth backwards yet the earth pushes you forward (somewhat like a car) ● This is a result of frictional forces. Without them, you couldn't walk (like on ice) or even hold a ladder against a wall. 
What happens when a ball hits a wall with reference to Newton's Laws?	● It will experience a change in momentum thus exerting a force on the wall. ● The wall will exert an equal and opposite force on the wall.
What is a moment defined as?	A force multiplied by the perpendicular distance between the pivot and the **line of action** of the force. *In essence, we're looking at the turning effect of a force. When we take moments about a point, we can ignore the force acting at the point. So never pick a point where you'd have to consider all distances and forces.*
What is the principle of moments?	"For any system **IN EQUILIBRIUM**, sum of clockwise moments = sum of anticlockwise moments."
What is a couple defined as and how is the moment of a couple calculated?	● A pair of equal and opposite coplanar forces. ● Force × perpendicular distance between the lines of action of the forces.

	 *As shown, it can be calculated by taking moments about the centre. Since the system isn't in equilibrium (as there's a resultant moment), you cannot use the principle of moments.*
What is the Centre of Mass and Centre of Gravity?	● Centre of mass is the point where all the mass seems to be concentrated. ● Centre of gravity is the point where all the weight seems to be concentrated. In a uniform gravitational field, both are in the same place.
How can you find the centre of mass of an object?	1. Freely suspend an irregular shape from a clamp. 2. Dangle a plumb line from the point of suspension and wait for the object to come to rest. 3. Draw a line following the string of the plumb line. 4. Repeat steps 1 - 3 for another point. The centre of mass is where both lines intersect.
When will an object rotate and topple (with an example)?	● It rotates when there is a resultant moment acting on it. ● It topples when the centre of mass acts outside the base. 

	● The clockwise moment $= Fd$ and the anticlockwise moment $= \frac{Wb}{2}$ (as the weight is in the middle).
What is the principle of the conservation of momentum?	“When two objects interact, the total momentum remains the same provided no external forces are acting.” *External forces include friction. They affect the total momentum as they can reduce the velocity of an object.*
What is impulse and how is it calculated?	The change in momentum calculated by multiply force by the time the force acts. $$F\Delta t = \Delta(mv)$$
Describe and explain the shape of the force-time graph of a steel ball bouncing off a surface	 ● This is analogous to jumping on a trampoline. The force the trampoline exerts back on you varies over time. At maximum deformation (the peak), the ball’s direction changes. ● The area under the graph is the total change in momentum. It goes from, let’s say, -5 $kgms^{-1}$ to 5 $kgms^{-1}$ thus half the graph is the initial momentum.
What happens in elastic, inelastic, and perfectly inelastic collisions?	● Elastic is when **BOTH** momentum and kinetic energy **IS** conserved. ● Inelastic is when momentum **IS** conserved **YET** kinetic energy **IS NOT**. ● Perfectly inelastic is where the colliding objects stick.
Give examples of elastic collisions using both equal and unequal masses	<u>**Equal masses:**</u> ● They swap so they carry on the momentum in a given direction. 

	 **<u>Unequal masses:</u>** ● If they move towards, they bounce off each other with the heavier object moving slower (as it will have more kinetic energy like in table tennis).  *The exact values are calculated by a slightly complicated equation which you can easily derive.*
Describe the stages of a skydiver jumping out a plane	1. He initially accelerates at $9.81ms^{-2}$. 2. Air resistances increases as he falls faster and faster until he reaches terminal velocity. 3. When the parachute opens, the force of air resistance increases drastically causing deceleration. 4. Air resistance balances his weight again when he reaches terminal velocity again. His weight remains constant throughout his dive.
How is energy transferred when accelerating and at terminal velocity during a skydive?	● Accelerating - GPE = KE + Q. ● Terminal velocity - GPE = Q (as work is being done again particles). Where Q is heat energy.
Projectile Motion	● *What happens horizontally is independent from what happens vertically.* ● *Thus if you drop a bullet and fire a bullet from the same height, they will reach the ground at the same time.* ● *Likewise, this is why you have to aim above a target to actually hit it. Think of the monkey-hunter scenario.*
What is work done?	The force multiplied the displacement in the direction of the force.

<table>
<tr><td>What is mechanical energy?</td><td>Energy due to the movement or position of an object (kinetic or potential).</td></tr>
<tr><td>Graphs</td><td>Distance is cumulative so a distance-time graph would never go down.</td></tr>
<tr><td>What is stopping distance and the factors affecting it?</td><td>Sum of thinking and braking distances.
<table>
<tr><th colspan="2">Factors affecting stopping distances</th></tr>
<tr><th>Thinking distance</th><th>Braking distance</th></tr>
<tr><td>Fatigue
Intoxication/drugs
Age
Distractions
Speed (∵ $s = ut$)</td><td>Brakes
Tyres
Road conditions
Speed</td></tr>
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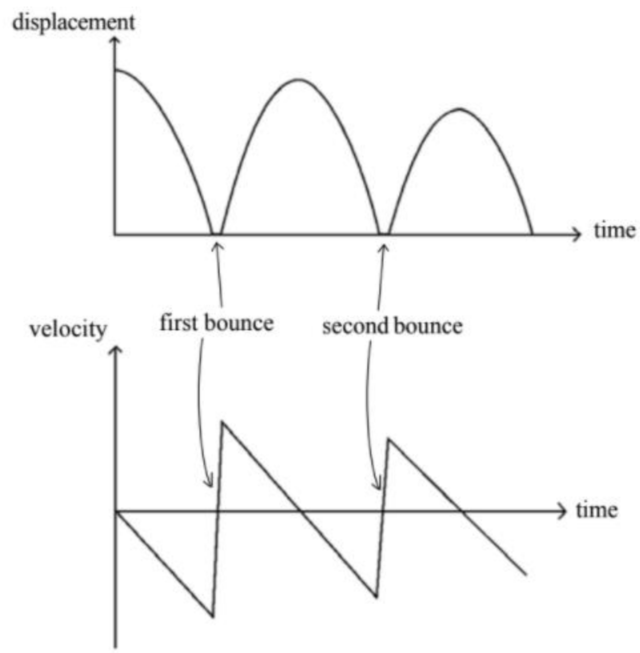
<tr><td>Sketch the velocity and displacement time graph of a bouncing ball with the ground being the origin</td><td>
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