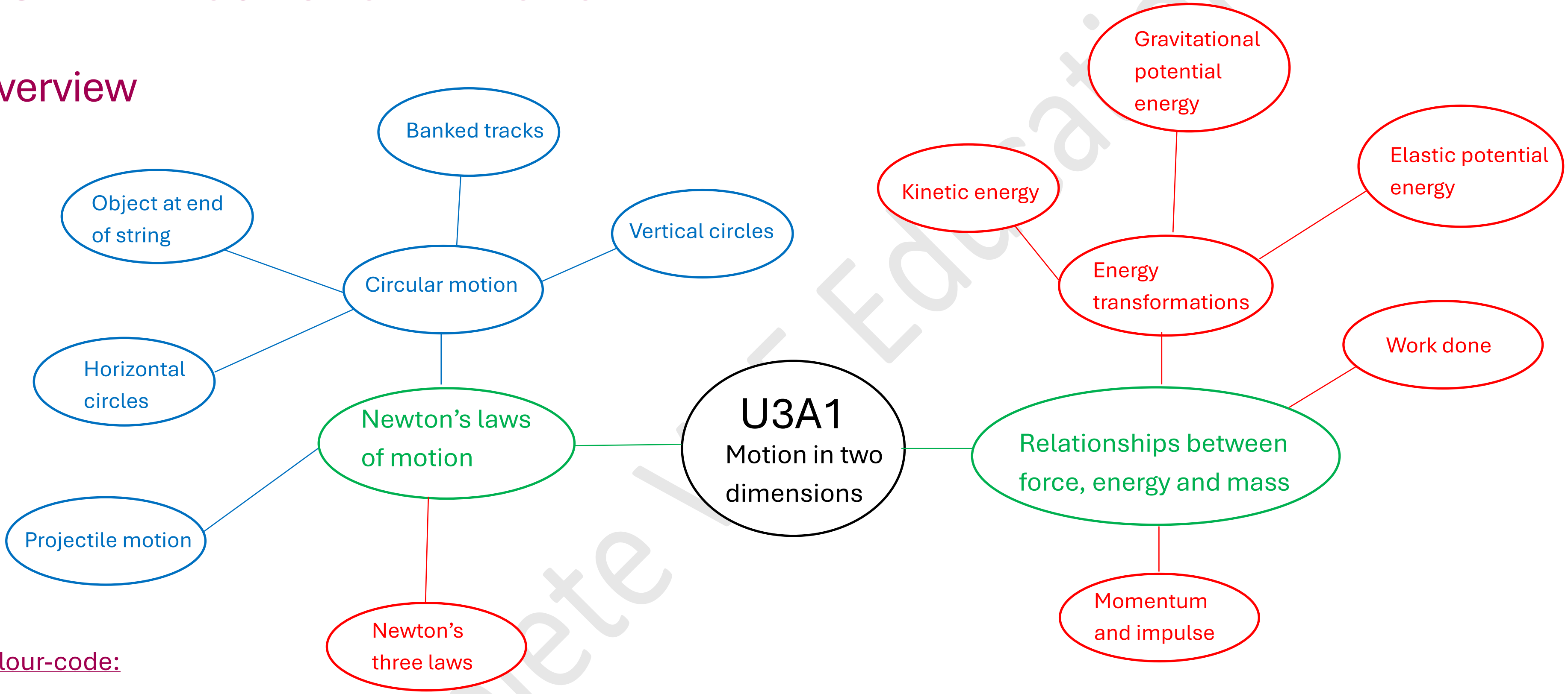
Complete VCE Education
VCE Physics Specialists

U3A1 Introduction - Motion

Overview



<u>Colour-code:</u>

Black = area of study

Green = topics within area of study

Blue = new in year 12

Red = also covered in year 11

Topic 1: Newton's laws of motion

Subtopic	Elaboration	Relevant Year 11 knowledge	Formulas and concepts	SAC/Exam tips	Example questions
Newton's Three Laws	Covers Newton's three laws of motion as well as the applications of these to more complex scenarios such as connected bodies and inclined planes.	• Labelling forces • Vectors and vector addition • Resolving vectors into perpendicular components • Newton's three laws • Inclined planes • Connected bodies (eg. involving pulleys or one object pulling the other)	• **Newton's first law**: an object at rest or moving at a constant velocity continues to do so unless acted on by an unbalanced force. • **Newton's second law:** $F_{net} = ma$ • **Newton's third law:** every action force has an equal and opposite reaction force, which act on different objects.	• Both theory and calculation questions possible, especially Newton's second law calculations. • Note: the gravitational force and normal force acting on the same object are **not** an action-reaction pair, as action-reaction forces must act on different objects.	• Calculate the magnitude of tension in the string connecting two masses. • Identify the reaction force to this action force.
Circular motion	Uniform circular motion occurs when the net force is constant and acts perpendicular to the object's velocity (towards the centre of the circle). The net force is called the centripetal force and results in the centripetal acceleration of an object into a circular path.	• Labelling forces • Vectors and vector addition • Resolving vectors into perpendicular components • Newton's second law	• **Centripetal force**: $F_c = \frac{mv^2}{r}$ • **Centripetal acceleration**: $a_c = \frac{v^2}{r}$ • **Velocity (uniform circular motion):** $v = \frac{2\pi r}{T}$ • Horizontal circular motion • Conical pendulums • Banked tracks • Vertical circles	• Mainly calculation problems, with occasional theory questions. • It is important to understand the forces involved in each of the above scenarios and how they add together to produce the centripetal force. • Derived formulas are not provided on the VCAA formula sheet, however these will save time when answering questions (see our U3A1 formula sheet).	• How do banked tracks allow vehicles to travel faster around corners? • Why do the occupants in the vehicle feel lighter when travelling over a hump? • Calculate the design speed of the banked track.

Projectile motion	The constant acceleration formulas covered in U2 AOS 1 will be applied in the context of two-dimensional motion, specifically parabolic projectile motion. Projectile motion can be divided into horizontal and vertical motion, which can be calculated separately.	• Resolving vectors into perpendicular components • Constant acceleration (suvat) formulas • Gravitational force	Constant acceleration formulas: • $v = u + at$ • $s = ut + \frac{1}{2}at^2$ • $s = vt - \frac{1}{2}at^2$ • $s = \frac{1}{2}(u + v)t$ • $v^2 = u^2 + 2as$	• Predominantly involve calculation questions, with rare theory questions. • For the vertical plane, remember to specify which direction is positive. • Horizontally, no forces are acting ($a = 0$), so the horizontal velocity is constant and can be calculated using $v = \frac{s}{t}$. • However, vertically, the gravitational force acts downwards, so the projectile experiences a downward acceleration due to gravity. Thus, suvat equations need to be used in the vertical plane. • Time is the variable that links horizontal and vertical motion.	• Calculate the horizontal distance travelled by the projectile. • Calculate the time taken for the projectile to reach its maximum height.

Topic 2: Relationships between force, energy and mass

Subtopic	Elaboration	Relevant Year 11 knowledge	Formulas and concepts	SAC/Exam tips	Example questions
Momentum and impulse	Momentum and impulse are both vectors and require a direction. Recall that impulse is equal to the change in momentum, as well as the product of the average force and time.	• Momentum • Conservation of momentum • Impulse and average force • Force-time graphs	• **Momentum**: $p = mv$ • **Impulse/change in momentum:** • $I = F_{av}t = \Delta p = m\Delta v$ • Impulse is also equal to the area under the force-time graph.	• May comprise a mix of theory questions and calculation questions. • Remember to assign one direction as positive and the other as negative when using the law of conservation of momentum. Questions regarding the law of conservation of momentum commonly involve: ○ Two objects colliding and staying separate ○ Two objects colliding and combining to form a single object after the collision ○ A single object splitting into two objects	• Explain how air bags protect occupants in terms of impulse. • Two objects collide and stick together. Calculate the final combined velocity.
Work done	Work is the transfer of energy from one object to another. When the force is constant, work done is the product of the displacement and the component of the net force in the direction of the displacement.	• Resolving vectors into perpendicular components • Work done when the force is constant • Force-distance graphs	• **Work done (if force and displacement in same direction):** $W = Fs$ • **Work done (if force and displacement not in same direction):** $W = Fs\cos\theta$ • $W = \Delta E$ (change in energy) • Work done is also equal to the area under the force-distance graph.	• Questions are usually calculation based and can be applied in other contexts such as uniform electric fields or gravitational fields. • It is important to distinguish between work done **on an object** (force and displacement in same direction) and work done **against an object** (force and displacement in opposite directions).	• A force is applied to pull an object. Calculate the final speed of the object after 10 m. • Calculate the magnitude of the frictional force acting on an object travelling at 3.0 m s^{-1}, given that it comes to a stop in 10 m.

Energy transformations	The law of conservation of energy states that energy cannot be created or destroyed, only transformed. Three types of energy will be explored; kinetic energy, gravitational potential energy and elastic potential energy, as well as energy transformations between these. Note that gravitational potential energy in this AOS will only be considered close to the Earth's surface, where g can be assumed constant. Scenarios involving large distances from Earth's surface, where g is not constant, will be covered in U3 AOS 2.	• Kinetic energy • Gravitational potential energy • Hooke's law • Elastic potential energy • Conservation of energy • Effects of friction	• **Kinetic energy:** $E_k = \frac{1}{2}mv^2$ • **Gravitational potential energy:** $E_g = mg\Delta h$ • Change in gravitational potential energy is also the area under the gravitational force-distance from centre of Earth graph. • **Hooke's Law:** $F_s = -k\Delta x$ • **Elastic potential energy:** $E_s = \frac{1}{2}k(\Delta x)^2$ • Change in elastic potential energy is also the area under the spring force-extension (or force-compression) graph. • **Elastic collisions:** total kinetic energy is conserved • **Inelastic collisions:** kinetic energy is not conserved (ie. some has been transformed into other forms such as heat, sound or the deformation of material).	• Mainly calculation but also theory questions. • The law of conservation of energy may be combined with concepts such as vertical circles. • Note: the formula sheet for the new study design states g to three significant figures ($g = 9.81\ m\ s^{-2}$). Students often struggle with questions involving **vertical springs**. • As a mass attached to a vertical spring falls, the gravitational force will remain constant while the spring force increases with the extension of the spring (Hooke's law). • Furthermore, the gravitational potential energy is maximal at the highest point and elastic potential energy will be maximal at the lowest point. • At the midpoint, $F_g = F_s$ so $F_{net} = 0$, and kinetic energy will be maximal. • Note that the total energy of the spring-mass system is the sum of its kinetic, elastic potential and gravitational potential energies.	• Determine whether this collision is elastic or inelastic. • Calculate the maximum extension of this vertical spring.