UNIT 5 Energy, Work and Power (M1)

Recommended Prior Knowledge. Students will need to have covered Unit 2 (Coordinate Geometry and Calculus) and it would be helpful, though not essential, if at least part of Unit 3 (Vectors) had also been completed. Unit 4 (Motion and force) must have been completed.

Context. This Unit must follow Unit 4, and ideally will be the last Unit in the AS course. This is only a small Unit, particularly when compared with Unit 4, and is only worth approximately 10% of the AS assessment.

Outline. The Unit starts with a study of the concept of the work done by a force and proceeds to link this with different forms of energy. This links with the Conservation of Energy (a concept likely to have been covered in the Physical Sciences) and concludes with a study of the concept of power.

N.B. Please read the notes at the end of the unit. These give further information on the setting and marking of questions on this topic.

Topic	Learning Outcomes	Suggested Teaching Activities	Resources	On-Line Resources
4	**Energy, work and power**			
	• Understand the concept of the work done by a force, and calculate the work done by a constant force when its point of application undergoes a displacement not necessarily parallel to the force (use of the scalar product is not required).	Introduce the concept of work done and look in detail at the definition along with the relevant units. Discuss the situation where the force is at an angle to the direction in which the particle will move. There is no need to link this with scalar product (though brighter students could be shown the use of **F.d**).		
	• Understand the concepts of gravitational potential energy and kinetic energy, and use appropriate formulae.	Look at the definition of energy and discuss with students different forms of energy. This will have been covered in science, but it does no harm in listing all the different types of energy (motion, position, chemical, heat, nuclear etc) and talking in general terms about different energy changes. In particular look at the energy changes that occur when an object falls freely, with or without air resistance, or when a particle is moving up a rough inclined plane and comes to rest.		

		Define gravitational potential energy and develop the formula "GPE=mgh" by using "work=force×distance". Define KE as $\frac{1}{2}mv^2$ and verify that this equates to "GPE=mgh" for a body moving with uniform acceleration. (More able students should be able to appreciate the more general proof of WD=FΔs = $m\int a\,ds = m\int v\,dv = \frac{1}{2}m(v^2-u^2)$). Show students that consideration of energy changes can be used to calculate speed and distance in simple cases of a particle moving under gravity with no air resistance.		
	• Understand and use the relationship between the change in energy of a system and the work done by the external forces, and use in appropriate cases the principle of conservation of energy.	Talk in general terms about the conservation of energy. Discuss the energy changes involved when a particle travels along a rough horizontal surface before coming to rest. Show students how such a problem can be solved either by considering the changes in energy (work done against resistance = loss in KE) or by calculating the deceleration (from $F=ma$) and using equations of uniform acceleration. Similarly look at problems involving a particle moving up, or down, or up and then down, a rough inclined plane. It is worth pointing out that consideration of work/energy shows that the speed at a point A on the way up will be greater than the speed at A on the way down and that the time from A to the highest point is less than the time from the highest point to A.	Have ready, on OHP slides, questions covering the principles of fairground rides.	
	• Use the definition of power as the rate at which a force does work, and use the relationship between power, force and velocity for a force acting in the direction of motion.	Talk in general terms about power and define power as the rate at which a force does work. Define the unit of a watt. Students will be aware of working at different rates, but are unlikely to have made specific calculations. They will be aware of the unit of a kilowatt (if only from electrical items, or from knowledge of the power output of a car or a plane). A good starting point of the value of a watt is to ask a volunteer to step on and off a chair as many times as		

		possible in a minute. It is not a difficult calculation to link changes in GPE (work done against gravity) and hence to calculate an approximate value for the power at which the student was working. (Can we ignore the KE being generated?) Students should be able to use "Power = WD/Time taken" in the case of constant power. Develop with the students the formula "Power = Fv" for a vehicle whose engine is producing a force of F N and which is travelling at a speed of $v$ms^{-1}.		
	Solve problems involving, for example, the instantaneous acceleration of a car moving on a hill with resistance.	Use this formula to look at problems of vehicles moving on either horizontal ground, or up or down a hill, at either constant speed or accelerating under a constant power output. The total resistance to the motion of the car should be taken into account.		

Please note:-

The unit refers to problems which can be solved either by considering work and energy, or by considering Newton's second law and (s, t, u, v, a) formulae for constant acceleration. It is important to emphasise that this choice is not available in the vast majority of problems set for examination where the aim is to test the topic 'use the relationship between change in energy and the work done by external forces'. The relevant problems fall into 4 categories.

(a) Those in which the motion is in a straight line and in which it can be inferred from the information of the question that the acceleration is constant.
(b) As (a) but for which the question specifically requires work/energy to be used.
(c) Those in which the motion is in a straight line and in which it cannot be inferred from the information of the question that the acceleration is constant, but the information nevertheless doesn't preclude it.
(d) Those in which it can be inferred from the information of the question that the acceleration is not constant (e.g. those in which the motion is in a curved path including fairground rides, those in which the driving force is provided by a constant power).

Clearly the choice is NOT available in the last three cases, and examination candidates score NO MARKS for the question in cases (b) and (d) if Newton's Second law or (s,t,u,v,a) formulae for constant acceleration are used.
In case (c) the examination mark scheme usually contains a special ruling to allow candidates to score some (but not all) of the marks when constant acceleration is implicitly assumed.