UNIT 1 Non-uniform acceleration

Recommended Prior Knowledge Students should have an understanding of vectors (AS Unit 1) and the analysis of distance-time and velocity-time graphs (AS unit 2). They should also have an appreciation of energy and energy changes (AS Unit 2).

Context This Unit introduces students to the topic of oscillations. The intention is to draw their attention to the effects of oscillations in everyday life and to prepare students for studies post A-level. The study of circular motion provides the basis for extension to cover satellite motion (A2 Unit 3) and the motion of charged particles in magnetic fields (A2 Unit 5).

Outline The Unit commences with a study of radian measure and circular motion. Non-uniform acceleration is then further developed by studying aspects of oscillations.

Online Resources. In this unit repeated use is made of Java Applets. These are usually well animated programmes. It has been found preferable to use one main source of computer programmes as both teachers and students can become familiar with the procedure for using the resource and are therefore more likely to connect to the web. This particular set of animations can be found using the web address http://surendranath.tripod.com . Once this has been found then the Applet menu enables the particular topic to be found. There is no need to subscribe to Tripod, just ignore their adverts and click on to either the Applets Menu or the 'Click here' instruction about any problem with the menu. Do read the instructions for each Applet by scrolling down past the 'Start Applet' command. In the Online Resources column reference will be made to this introduction and then the Applet menu title will be given. Where other addresses are used it is because the Applets do not cover the particular topic.

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
	Motion in a circle			
7(a)	Express angular displacement in radians.	The radian should be defined and students should know that 2π rad = 360°		Make a protractor which measures in radians
7(b)	Understand and use the concept of angular velocity to solve problems.		See introduction. Applet: Kinematics – Circle Plus. Make $V_x = 0$ for circular motion	
7(c)	Recall and use $v = r\omega$ to solve problems			9702/4 May 02, 1(b)
7(d)	Describe qualitatively motion in a curved path due to a perpendicular force, and understand the centripetal acceleration in the case of uniform motion in a circle.	Although the formulae for circular motion do not have to be derived, candidates should use vector subtraction of velocities to convince themselves that the acceleration is towards the centre of the circle.	Applet: Math – Vector addition	All Advanced Level textbooks deal with this topic in detail. Books are listed below and further details of the books are given on the CIE website www.CIE.org.uk
7(e)	Recall and use centripetal acceleration $a = r\omega^2$, $a = v^2/r$.			

7(f)	Recall and use centripetal force $F = mr\omega^2$, $F = mv^2/r$.	Students should carry out a simple experiment to verify the dependence of F on r and ω. Consideration of a conical pendulum will reinforce the fact that centripetal force is a resultant force.		A piece of rope and a bucket a quarter full of water swung vertically makes a memorable demonstration
14(a)	**Oscillations** Describe simple examples of free oscillations.	Students should be encouraged to list examples and to discover what is meant by an oscillation.		Understanding Physics for Advanced Level:Breithaupt ISBN: 0748743146
14(b) 14(c)	Investigate the motion of an oscillator using experimental and graphical techniques. Understand and use the terms amplitude, period, frequency, angular frequency and phase difference and express the period in terms of both frequency and angular frequency.	A pendulum or mass-spring system are very satisfactory. This is an ideal opportunity to use motion sensors and data-loggers. If not available, then the motion of a very long pendulum can be studied. Initially, a displacement-time graph should be obtained, leading to an understanding of displacement, amplitude, frequency and period. SHM should be defined.	See introduction. Applets: S.H.M.- phase -phase difference	Physics: Hutchings ISBN 0174387318 Physics 2: Sang (Editor) ISBN 0521797152 9702/4 Nov 02, 3(a) 9702/4 May 02, 4(a)
14(d) 14(g) 14(e)	Recognise and use the equation $a = -\omega^2x$ as the defining equation of simple harmonic motion. Describe, with graphical illustrations, the changes in displacement, velocity and acceleration during simple harmonic motion. Recall and use $x = x_0\sin\omega t$ as a solution of the equation $a = -\omega^2x$.	A point rotating in a circle at 33 rpm has the same value for ω as a pendulum of length 120 cm. If the shadows of a pencil on a record player turntable and the pendulum bob are projected onto a screen, then the shadows can be made to move together. This gives a meaning to ω. The shadows may be used to illustrate phase difference. ‘Lead’ and ‘lag’ should be illustrated.		

14(f)	Recognise and use $v = v_0\cos\omega t$, $v = \pm\omega\sqrt{(x_0^2 - x^2)}$.	A double beam oscilloscope may also be used to illustrate phase difference. The gradient of the x/t should be analysed to obtain a v/t graph, even if motion sensors are available. It should be emphasised that the a/x graph is not sinusoidal. It should be made clear that, for constant amplitude, the *total* energy of the system is constant.	See introduction. Applets: S.H.M.- forced oscillations	9702/4 May 02, 4(a) 9702/4 May 02, 4(b)
14(h)	Describe the interchange between kinetic and potential energy during simple harmonic motion.	$E_k = ½m\omega^2(x_0^2 - x^2)$ $E_{tot} = ½m\omega^2 x_0^2$ $E_p = ½m\omega^2 x^2$ Energy-displacement graphs should be sketched.		
14(i)	Describe practical examples of damped oscillations with particular reference to the effects of the degree of damping and the importance of critical damping in cases such as a car suspension system.	Damping should be described as a consequence of a force dissipating the total energy of the oscillator. The force always acts to oppose the motion and causes the amplitude to decrease. Examples of light, critical and heavy damping should be studied, together with x/t graphs. Specific reference to a car suspension system may be made in an examination.	See introduction. Applets: S.H.M.- forced oscillations	9702/4 Nov 02, 3(a)
14(k)	Describe graphically how the amplitude of a forced oscillation changes with frequency near to the natural frequency of the system, and understand qualitatively the factors which determine the frequency response and sharpness of the resonance.	Natural frequency and impressed (forced) frequency of vibration should be introduced. The oscillations of a mass-spring system where the spring is supported on a variable-frequency oscillator should be studied. Damping can be varied using thin card of different areas attached to the mass.	See introduction. Applets: S.H.M.- forced oscillations	9702/4 Nov 02, 3(b)
14(j)	Describe practical examples of forced oscillations and resonance.	Different examples should be studied. Where a specific example is quoted in an examination, then full details will be provided.		

14(l)	Show an appreciation that there are some circumstances in which resonance is useful and other circumstances in which resonance should be avoided.			Useful: e.g. organ pipes, brass and woodwind musical instruments, oscillator circuits, microwave ovens. Resonance to be avoided in: machinery, bridges, buildings in earthquake zones, aircraft, loudspeakers.