Sets (s): All students

YEAR 13

SUBJECT Physics LP1

Knowledge Focus: Vibrations, electrostatic and gravitational fields, kinetic theory of gases

Ysgol Uwchradd Prestatyn High School

This half term : Skills, Knowledge and Understanding to be developed:

We will start this year studying oscillations and their applications to everyday problems. We will also study the concept of electric and gravitational fields and how they relate to forces.

Key Terms to be learned this half term:

period, frequency, angular velocity, angular acceleration, centripetal force, harmonic motion, amplitude, phase, damped oscillations, electrostatic and gravitational fields, field lines, equipotential surfaces

Dr Clayton: Electric and gravitational fields
Learning Objectives etc:

- the features of electric and gravitational fields as specified in the table in the last page of the learning plan
- the idea that the gravitational field outside spherical bodies such as the Earth is essentially the same as if the whole mass were concentrated at the centre
- field lines (or lines of force) giving the direction of the field at a point, thus, for a positive point charge, the field lines are radially outward
- equipotential surfaces joining points of equal potential and are therefore spherical for a point charge
- how to calculate the net potential and resultant field strength for a number of point charges or point masses
- the equation $\Delta U_P = mg\Delta h$ for distances over which the variation of g is negligible

Specified practical work : None

Objective assessments:

Completion of past paper questions.

Homework:

Past exam questions.

Extension:

IsaacPhysics problems

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Dr Athanasopoulos: Vibrations
Learning Objectives etc:

- the definition of simple harmonic motion as a statement in words
- $a=-\omega^2x$ as a mathematical defining equation of simple harmonic motion
- the graphical representation of the variation of acceleration with displacement during simple harmonic motion
- $x=A\cos(\omega t + \varepsilon)$ as a solution to $a=-\omega^2x$
- the terms frequency, period, amplitude and phase
- period as $1/f$ or $2\pi/\omega$
- $v=-A\omega\sin(\omega t + \varepsilon)$ for the velocity during simple harmonic motion
- the graphical representation of the changes in displacement and velocity with time during simple harmonic motion
- the equation $T = 2\pi\sqrt{\frac{m}{k}}$ for the period of a system having stiffness (force per unit extension) k and mass m
- the equation $T = 2\pi\sqrt{\frac{l}{g}}$ for the period of a simple pendulum
- the graphical representation of the interchange between kinetic energy and potential energy during undamped simple harmonic motion, and perform simple calculations on energy changes
- free oscillations and the effect of damping in real systems
- practical examples of damped oscillations
- the importance of critical damping in appropriate cases such as vehicle suspensions
- forced oscillations and resonance, and to describe practical examples
- the variation of the amplitude of a forced oscillation with driving frequency and that increased damping broadens the resonance curve
- circumstances when resonance is useful for example, circuit tuning, microwave cooking and other circumstances in which it should be avoided for example, bridge design

Specified practical work

Measurement of g with a pendulum

Investigation of the damping of a spring

Objective assessments:

Completion of past paper questions.

APP

None

Homework:

Past exam questions.

Extension:

IsaacPhysics problems

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Dr Athanasopoulos: Kinetic theory
Learning Objectives etc:

- the equation of state for an ideal gas expressed as pV=nRT where R is the molar gas constant and pV=NkT where k is the Boltzmann constant
- the assumptions of the kinetic theory of gases which includes the random distribution of energy among the molecules
- the idea that molecular movement causes the pressure exerted by a gas, and use $p = \frac{1}{3}\rho\overline{c^2} = \frac{1}{3}\frac{N}{V}m\overline{c^2}$ where N is the number of molecules
- the definition of Avogadro constant N_A and hence the mole
- the idea that the molar mass M is related to the relative molecular mass M_r by M/kg= M_r/1000 and that the number of moles n is given by $\frac{total\ mass}{molar\ mass}$
- how to combine pV=$\frac{1}{3}Nm\overline{c^2}$ with pV = nRT and show that the total translational kinetic energy of a mole of a monatomic gas is given by 3/2RT and
- the mean kinetic energy of a molecule is 3/2kT where k=$\frac{R}{N_A}$ is the Boltzmann constant, and that T is proportional to the mean kinetic energy

Specified practical work

None

Objective assessments:

Completion of past paper questions.

SA

None

Homework:

Past exam questions.

Extension:

IsaacPhysics problems

Terms for sections 3.1-3.2: Resonance, Angular velocity, Phase, Period, Frequency, Amplitude, Forced oscillations, Damping, Simple harmonic motion (shm), Period, Radian, Frequency, Free oscillations [Natural oscillations], Critical damping

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Section	Item	Definition
3.1 (a)		Time taken for one complete circuit.
		The number of circuits or cycles per second.
3.1 (b)		A unit of measurement of angles equal to about 57.3°, equivalent to the angle subtended at the centre of a circle by an arc equal in length to the radius. **UNIT: rad**
3.1 (d)		For an object describing a circle at uniform speed, ω is equal to the angle θ swept out by the radius in time Δt divided by t $\left(\omega = \frac{\Delta\theta}{\Delta t}\right)$ **UNIT: rad s^{-1}**
3.2 (a)		This occurs when an object moves such that its acceleration is always directed toward a fixed point and is proportional to its distance from the fixed point. ($a = -\omega^2 x$) **Alternative definition:** The motion of a point whose displacement x changes with time t according to $x = A\cos(\omega t + \varepsilon)$, where A, ω and ε are constants. [Variations of this kind are said to be *sinusoidal*.]
3.2 (e)		The time taken for one complete cycle.
		The maximum value of the object's displacement (from its equilibrium position).
		The angle ($\omega t + \varepsilon$) in the equation $x = A\cos(\omega t + \varepsilon)$. [$\varepsilon$ is called the *phase constant*.] **UNIT: rad**
		The number of oscillations per second. **UNIT: Hz**
3.2 (l)		Free oscillations occur when an oscillatory system (such as a mass on a spring, or a pendulum) is displaced and released. [The frequency of the free oscillations is called the system's *natural frequency*.]
		The dying away, due to resistive forces, of the amplitude of free oscillations.
3.2 (n)		The case when the resistive forces on the system are just large enough to prevent oscillations occurring at all when the system is displaced and released.
3.2 (o)		These occur when a sinusoidally varying 'driving' force is applied to an oscillatory system, causing it to oscillate with the frequency of the applied force.
		If, in forced vibrations, the frequency of the applied force is equal to the natural frequency of the system (e.g. mass on spring), the amplitude of the resulting oscillations is large. This is ____________.

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Features of electric and gravitational fields

ELECTRIC FIELDS	GRAVITATIONAL FIELDS
Electric field strength, E, is the force per unit charge on a small positive test charge placed at the point	Gravitational field strength, g, is the force per unit mass on a small test mass placed at the point
Inverse square law for the force between two electric charges in the form $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ (Coulomb's law)	Inverse square law for the force between two masses in the form $F = G\frac{M_1M_2}{r^2}$ (Newton's law of gravitation)
F can be attractive or repulsive	F is attractive only
$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$ for the field strength due to a point charge in free space or air	$g = \frac{GM}{r^2}$ for the field strength due to a point mass
Potential at a point due to a point charge in terms of the work done in bringing a unit positive charge from infinity to that point	Potential at a point due to a point mass in terms of the work done in bringing a unit mass from infinity to that point
$V_E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ and $PE = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r}$	$V_g = -\frac{GM}{r}$ and $PE = -\frac{GM_1M_2}{r}$
Change in potential energy of a point charge moving in any electric field $= q\Delta V_E$	Change in potential energy of a point mass moving in any gravitational field $= m\Delta V_g$
Field strength at a point is given by E = - slope of the $V_E - r$ graph at that point	Field strength at a point is given by g = - slope of the $V_g - r$ graph at that point
Note that $\frac{1}{4\pi\varepsilon_0} \approx 9 \times 10^9\ \mathrm{F^{-1}m}$ is an acceptable approximation	