Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 7 3 4 / 0 1	Signature	

Paper Reference(s)

6734/01

Edexcel GCE

Physics

Advanced Level

Unit Test PHY4

Monday 21 January 2008 – Morning

Time: 1 hour 20 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
Total	

Materials required for examination	**Items included with question papers**
Nil	Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initials and signature.
Answer **ALL** questions in the spaces provided in this question paper.
In calculations you should show all the steps in your working, giving your answer at each stage.
Calculators may be used.
Include diagrams in your answers where these are helpful.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets.
There are seven questions in this paper. The total mark for this paper is 60.
The list of data, formulae and relationships is printed at the end of this booklet.

Advice to Candidates

You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, taking account of your use of grammar, punctuation and spelling.

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1. (a) The Earth rotates about its axis. Show that its angular speed is approximately 7×10^{-5} rad s^{-1}.

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(2)

(b) A stone is resting on the ground at a point on the equator.

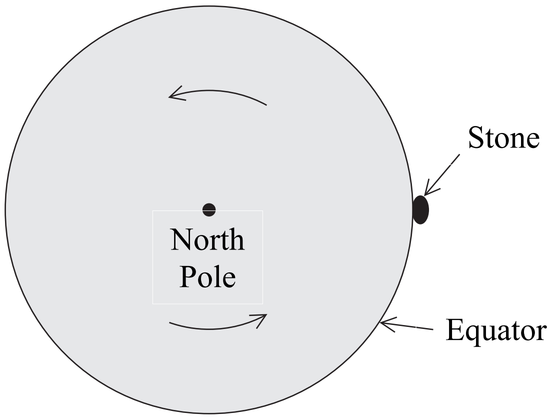

Figure 1

(i) The radius of the Earth is 6400 km. Calculate the acceleration of the stone as it follows its circular path.

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....

Acceleration = ...

(2)

(ii) Draw an arrow on Figure 1 to show the direction of the stone's acceleration.

(1)

Leave blank

(iii) In the space below, draw a labelled free-body force diagram for the stone when it is at the point shown in Figure 1.

(2)

(iv) With reference to your free-body force diagram, explain how the stone's acceleration is produced.

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(2)

Q1

(Total 9 marks)

N 2 9 2 4 4 A 0 3 2 0

Turn over

2. (a) A mass hangs on a spring suspended from a fixed point. When displaced and released, the mass oscillates in a vertical direction. Describe how you could determine accurately the frequency f_0 of these oscillations. You may be awarded a mark for the clarity of your answer.

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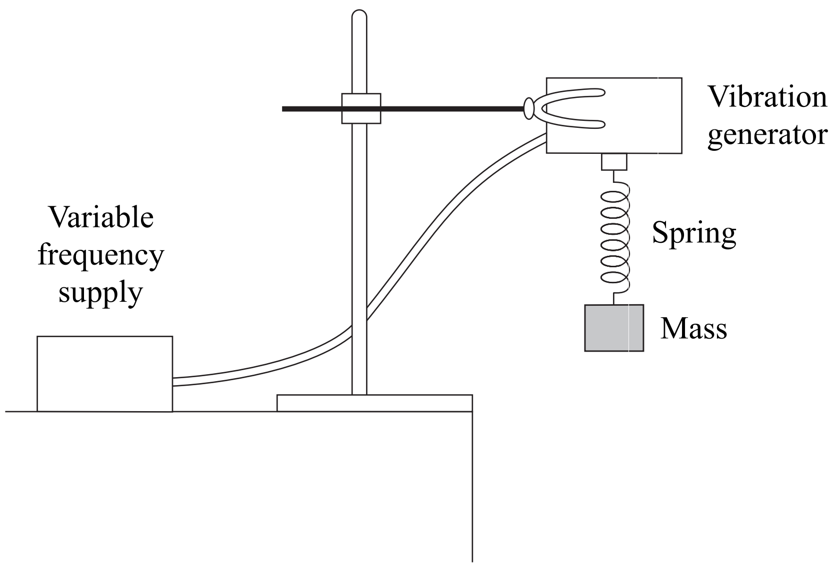
(4)

(b) The mass and spring are now attached to a vibration generator.



A short time after the vibration generator is turned on, the mass settles down and performs simple harmonic motion at the frequency of the generator.

Leave blank

Leave blank

(i) Label the axes below and sketch a graph showing how the amplitude of this oscillation changes as the frequency is varied up to and well beyond f_0.
Mark the approximate position of f_0 on the frequency axis.

(3)

(ii) State the name of the phenomenon illustrated by your graph.

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(1)

(iii) This phenomenon can cause problems in the design of footbridges. Explain why.

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(2)

Q2

(Total 10 marks)

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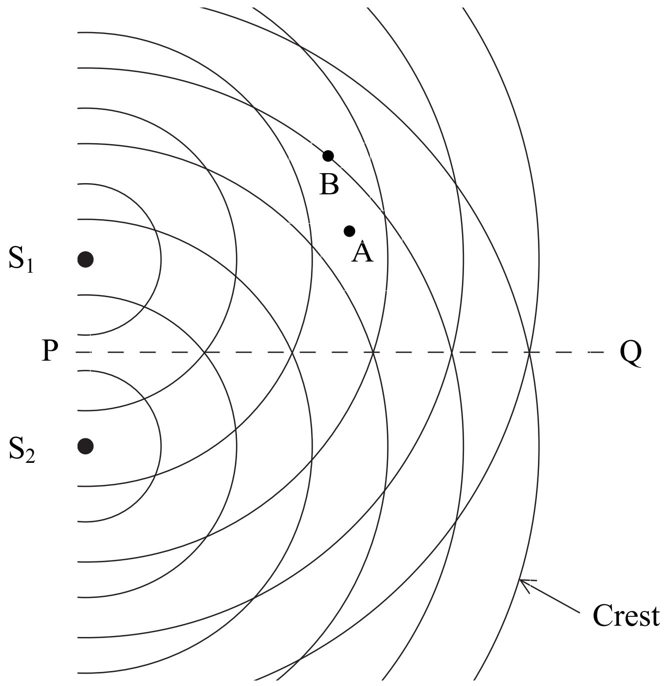
3. Two point sources, S_1 and S_2, emit waves of equal amplitude and frequency. The diagram, which is full size, shows the positions of successive crests of each wave at one particular instant of time.



(a) (i) How can you tell from the diagram that the speed of the waves is the same everywhere?

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(1)

(ii) The frequency of the waves is 40 Hz. Use information from the diagram to determine their speed.

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Speed = ...

(3)

(b) On the diagram, draw a line joining points where the waves from S_1 have travelled one wavelength further than the waves from S_2. Label this line X.

(1)

Leave blank

(c) The waves from the two sources superpose.

(i) Describe and explain the result of this superposition along line PQ.

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....
(3)

(ii) Tick the appropriate boxes in the table to show what is observed at the points marked A and B in the diagram.

Point	**What is observed**		
	Constructive interference	**Destructive interference**	**Neither**
A			
B			

(2)

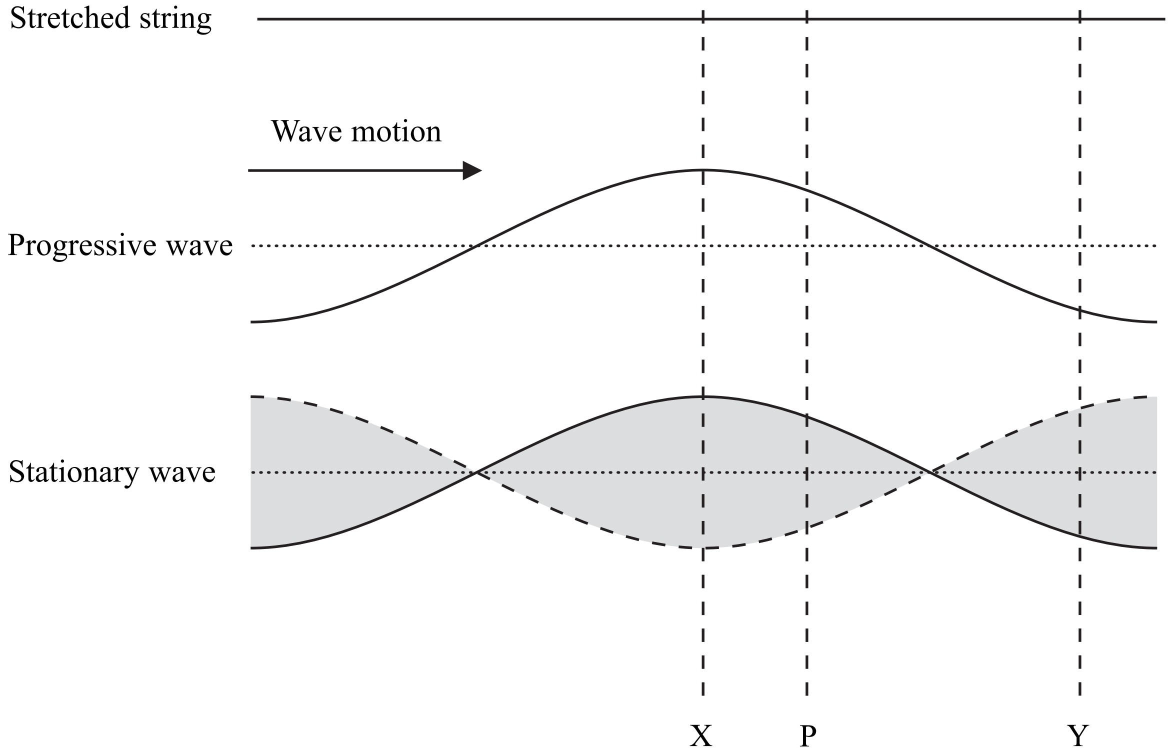
Q3

(Total 10 marks)

Leave blank

4. The diagrams show

- a stretched string
- a sinusoidal progressive wave travelling to the right along the string
- a stationary wave on the same string.



P is at a distance from X which can be varied.

(a) How, if at all, does the **amplitude** of oscillation at P vary as P moves from X to Y

(i) in the progressive wave?

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(1)

(ii) in the stationary wave?

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....

(2)

Leave blank

(b) How, if at all, does the **phase difference** between the oscillations at X and at P vary as P moves from X to Y

(i) in the progressive wave?

....

(1)

(ii) in the stationary wave?

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....

(2)

Q4

(Total 6 marks)

Leave blank

5. (a) The maximum wavelength of electromagnetic radiation which can release photoelectrons from the surface of caesium is 6.5×10^{-7} m.

(i) State the part of the electromagnetic spectrum to which this radiation belongs.

....

(1)

(ii) Show that caesium has a work function φ of about 3×10^{-19} J.

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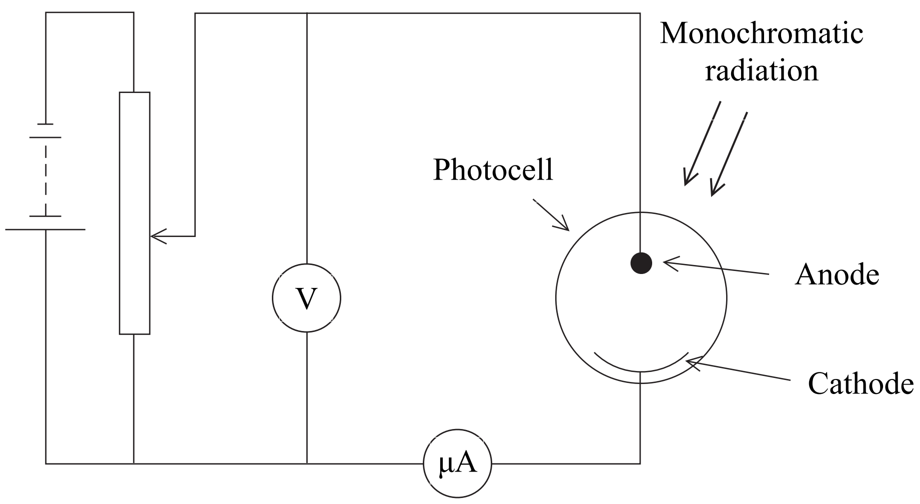
(2)

(b) The caesium cathode of a photocell is illuminated by radiation of frequency *f*. The circuit shown is used to measure the stopping potential V_s for a range of frequencies.



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(i) Explain what is meant by the term **stopping potential**.

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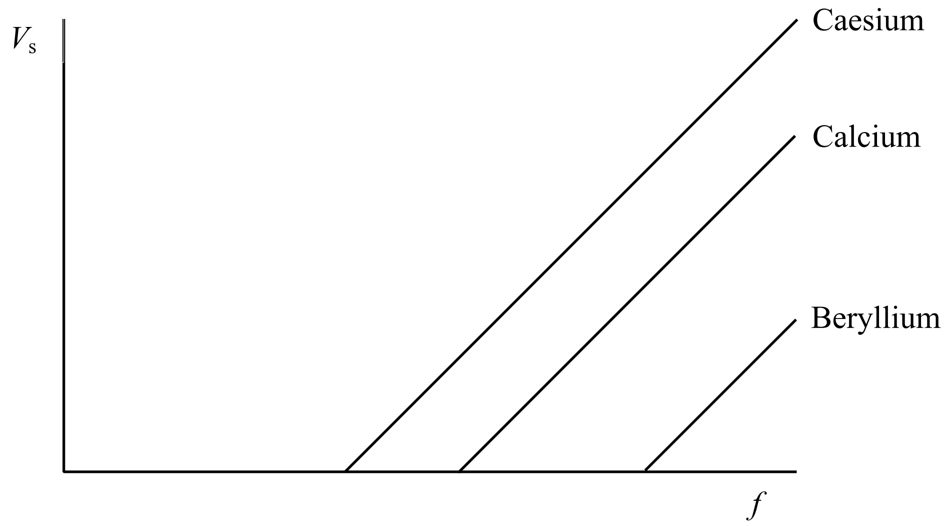
(2)

(ii) The experiment is repeated, using different photocells, to measure the stopping potentials of calcium and beryllium. The graph shows how the stopping potentials V_s for all three metals vary with frequency f.



Use the relationship

$$hf = eV_s + \varphi$$

to explain why all three graphs are parallel.

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(2)

Q5

(Total 7 marks)

N 2 9 2 4 4 A 0 1 1 2 0

Turn over

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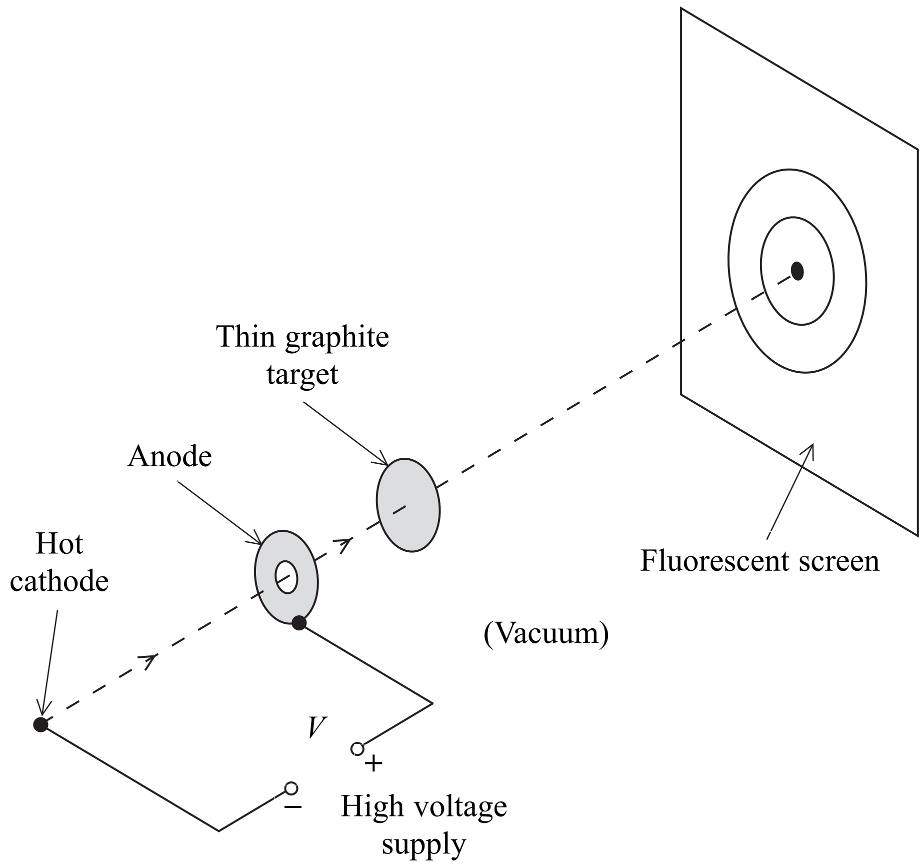
6. The diagram shows the principle of an experiment using electrons.



Electrons are accelerated from rest through a potential difference V in a vacuum. The electron beam then strikes a thin target composed of graphite crystals. Bright rings are seen on a fluorescent screen beyond the target.

(a) (i) Name the effect which produces the ring pattern.

....

(1)

(ii) Explain how, in this experiment, electrons display both wave and particle properties.

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(2)

N 2 9 2 4 4 A 0 1 2 2 0

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(b) A suitable de Broglie wavelength for the electrons in this experiment is 2.0×10^{-11} m.

(i) Explain why this value is suitable.

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(2)

(ii) Show that the momentum of one of these electrons is approximately 3.3×10^{-23} kg m s^{-1}.

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(2)

(iii) Show that the electron's kinetic energy is approximately 4 keV.

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....

(4)

(iv) What accelerating potential difference would produce electrons with this kinetic energy?

P.d. = ...

(1)

Q6

(Total 12 marks)

Leave blank

7. A line in the hydrogen spectrum from a laboratory source has a wavelength of 656 nm.

(a) In the spectrum of light received from a distant galaxy X, this line appears at a wavelength of 684 nm. Calculate the speed of recession of galaxy X.

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....

Speed = ...

(3)

(b) A second galaxy Y is twice as far from the Earth as galaxy X. At what wavelength would you expect the same line to appear in the spectrum of light received from Y? Explain your reasoning.

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....

....

Wavelength = ...

(3) **Q7**

(Total 6 marks)

TOTAL FOR PAPER: 60 MARKS

END

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
Acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$	(close to the Earth)
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to the Earth)
Elementary (proton) charge	$e = 1.60 \times 10^{-19} \text{ C}$	
Electronic mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27} \text{ kg}$	
Molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$	
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Coulomb Law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ N A}^{-2}$	
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$	

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$

$$x = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2ax$$

Forces and moments

Moment of F about O = $F \times$ (Perpendicular distance from F to O)

Sum of clockwise moments about any point in a plane = Sum of anticlockwise moments about that point

Dynamics

Force $\quad F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$

Impulse $\quad F\Delta t = \Delta p$

Mechanical energy

Power $\quad P = Fv$

Radioactive decay and the nuclear atom

Activity $\quad A = \lambda N \quad$ (Decay constant λ)

Half-life $\quad \lambda t_{\frac{1}{2}} = 0.69$

Electrical current and potential difference

Electric current $I = nAQv$

Electric power $P = I^2R$

Electrical circuits

Terminal potential difference $V = \mathcal{E} - Ir$ (E.m.f. $\mathcal{E}$; Internal resistance r)

Circuit e.m.f. $\Sigma\mathcal{E} = \Sigma IR$

Resistors in series $R = R_1 + R_2 + R_3$

Resistors in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Heating matter

Change of state: energy transfer $= l\Delta m$ (Specific latent heat or specific enthalpy change l)

Heating and cooling: energy transfer $= mc\Delta T$ (Specific heat capacity c; Temperature change ΔT)

Celsius temperature $\theta/°\mathrm{C} = T/\mathrm{K} - 273$

Kinetic theory of matter

Temperature and energy $T \propto$ Average kinetic energy of molecules

Kinetic theory $p = \frac{1}{3}\rho\langle c^2\rangle$

Conservation of energy

Change of internal energy $\Delta U = \Delta Q + \Delta W$ (Energy transferred thermally ΔQ; Work done on body ΔW)

Efficiency of energy transfer $= \frac{\text{Useful output}}{\text{Input}}$

Heat engine: maximum efficiency $= \frac{T_1 - T_2}{T_1}$

Circular motion and oscillations

Angular speed $\omega = \frac{\Delta\theta}{\Delta t} = \frac{v}{r}$ (Radius of circular path r)

Centripetal acceleration $a = \frac{v^2}{r}$

Period $T = \frac{1}{f} = \frac{2\pi}{\omega}$ (Frequency f)

Simple harmonic motion:

displacement $x = x_0 \cos 2\pi ft$

maximum speed $= 2\pi fx_0$

acceleration $a = -(2\pi f)^2 x$

For a simple pendulum $T = 2\pi\sqrt{\frac{l}{g}}$

For a mass on a spring $T = 2\pi\sqrt{\frac{m}{k}}$ (Spring constant k)

Waves

Intensity	$I = \dfrac{P}{4\pi r^2}$	(Distance from point source r; Power of source P)

Superposition of waves

Two slit interference	$\lambda = \dfrac{xs}{D}$	(Wavelength λ; Slit separation s; Fringe width x; Slits to screen distance D)

Quantum phenomena

Photon model	$E = hf$	(Planck constant h)
Maximum energy of photoelectrons	$= hf - \varphi$	(Work function φ)
Energy levels	$hf = E_1 - E_2$	
de Broglie wavelength	$\lambda = \dfrac{h}{p}$	

Observing the Universe

Doppler shift	$\dfrac{\Delta f}{f} = \dfrac{\Delta\lambda}{\lambda} \approx \dfrac{v}{c}$	
Hubble law	$v = Hd$	(Hubble constant H)

Gravitational fields

Gravitational field strength	$g = F/m$	
for radial field	$g = Gm/r^2$, numerically	(Gravitational constant G)

Electric fields

Electrical field strength	$E = F/Q$	
for radial field	$E = kQ/r^2$	(Coulomb law constant k)
for uniform field	$E = V/d$	
For an electron in a vacuum tube	$e\Delta V = \Delta(\frac{1}{2}m_e v^2)$	

Capacitance

Energy stored	$W = \frac{1}{2}CV^2$	
Capacitors in parallel	$C = C_1 + C_2 + C_3$	
Capacitors in series	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$	
Time constant for capacitor discharge	$= RC$	

Magnetic fields

Force on a wire $F = BIl$

Magnetic flux density (Magnetic field strength)

in a long solenoid $B = \mu_0 nI$ (Permeability of free space μ_0)

near a long wire $B = \mu_0 I / 2\pi r$

Magnetic flux $\Phi = BA$

E.m.f. induced in a coil $\varepsilon = -\dfrac{N\Delta\Phi}{\Delta t}$ (Number of turns N)

Accelerators

Mass-energy $\Delta E = c^2 \Delta m$

Force on a moving charge $F = BQv$

Analogies in physics

Capacitor discharge $Q = Q_0 e^{-t/RC}$

$$\frac{t_{\frac{1}{2}}}{RC} = \ln 2$$

Radioactive decay $N = N_0 e^{-\lambda t}$

$$\lambda t_{\frac{1}{2}} = \ln 2$$

Experimental physics

$$\text{Percentage uncertainty} = \frac{\text{Estimated uncertainty} \times 100\%}{\text{Average value}}$$

Mathematics

$$\sin(90° - \theta) = \cos\theta$$

$$\ln(x^n) = n \ln x$$

$$\ln(e^{kx}) = kx$$

Equation of a straight line $y = mx + c$

Surface area cylinder $= 2\pi rh + 2\pi r^2$

sphere $= 4\pi r^2$

Volume cylinder $= \pi r^2 h$

sphere $= \frac{4}{3}\pi r^3$

For small angles: $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

$\cos\theta \approx 1$

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