

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel**  
International  
Advanced Level

Centre Number

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Candidate Number

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**Friday 5 June 2020**

Afternoon (Time: 1 hour 20 minutes)

Paper Reference **WPH16/01**

**Physics**

**International Advanced Level**

**Unit 6: Practical Skills in Physics II**

**You must have:**

Scientific calculator, Ruler

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- **Show all your working out in calculations and include units where appropriate.**

### Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The list of data, formulae and relationships is printed at the end of this booklet.

### Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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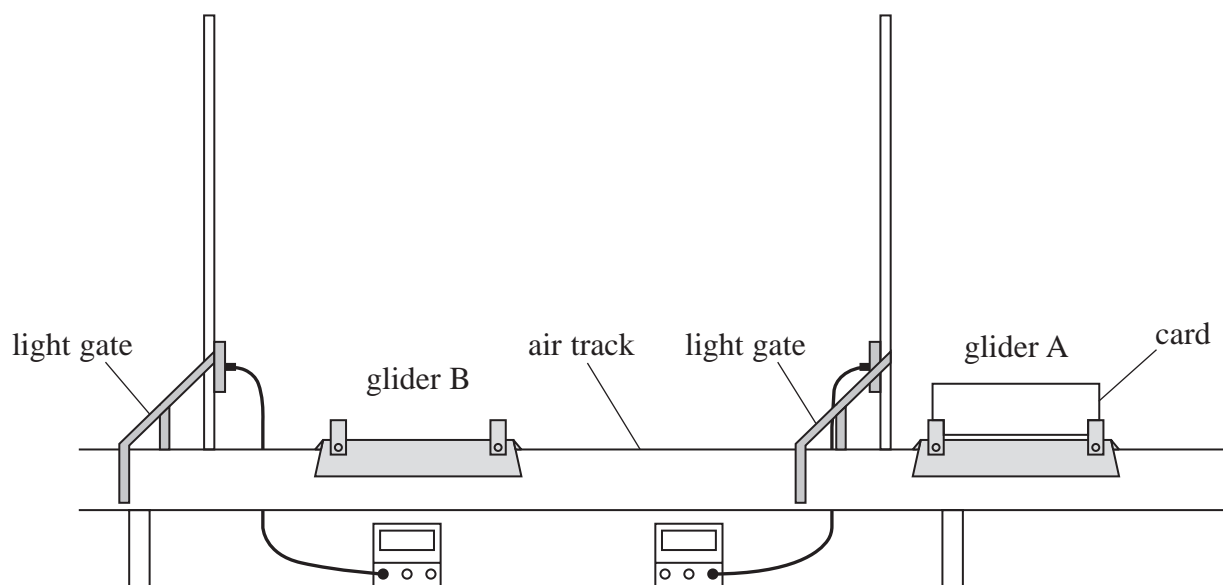
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Pearson

Answer ALL questions.

- 1 A student investigated the conservation of momentum using the apparatus as shown.



- (a) The air track provides a cushion of air which reduces friction between the gliders and the track.

Describe how the student would show that the air track is horizontal before starting the investigation.

(1)

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- (b) The student pushed glider A. The first light gate recorded the time  $t_1$  for the card on glider A to pass through it.

The gliders collided and stuck together. The second light gate recorded the time  $t_2$  for the card on glider A to pass through it.

The student recorded  $t_1$  and  $t_2$  for three separate collisions.

$t_1/s$	0.34	0.21	0.28
$t_2/s$	0.70	0.39	0.55

The masses of the gliders were identical. If momentum is conserved then  $t_2 = 2t_1$ .

Show that momentum was conserved in this investigation.

(3)

- (c) Another student suggested that using a piece of card twice as long would improve the investigation.

Assess this suggestion.

(3)

(Total for Question 1 = 7 marks)





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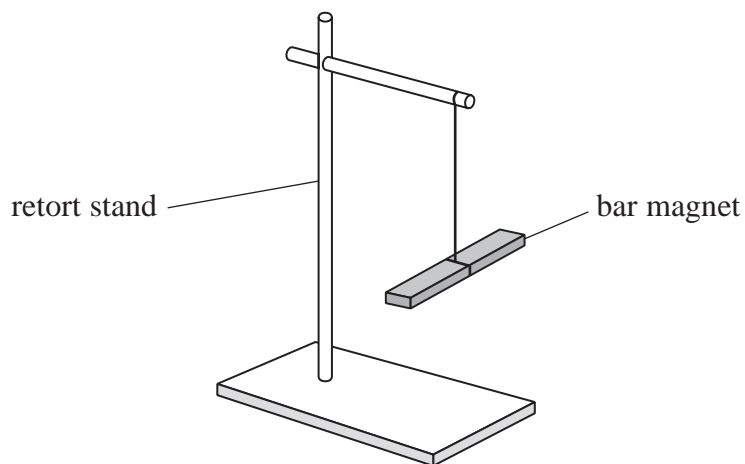
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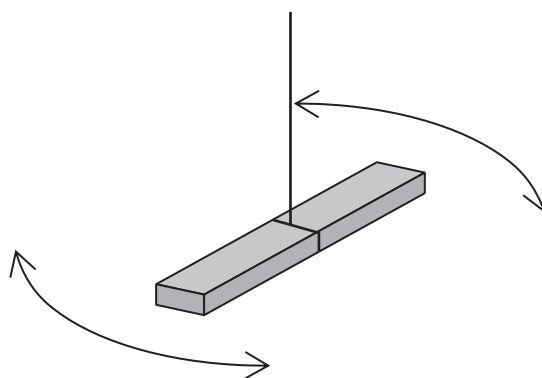


- 3 A bar magnet was suspended from a wooden retort stand as shown.



The magnet lined up with the magnetic field of the Earth.

The magnet was given a small angular displacement from its equilibrium position and oscillated in a horizontal plane about the string as shown.



- (a) Describe how the time period of these oscillations should be measured to make the readings as accurate as possible.

(3)

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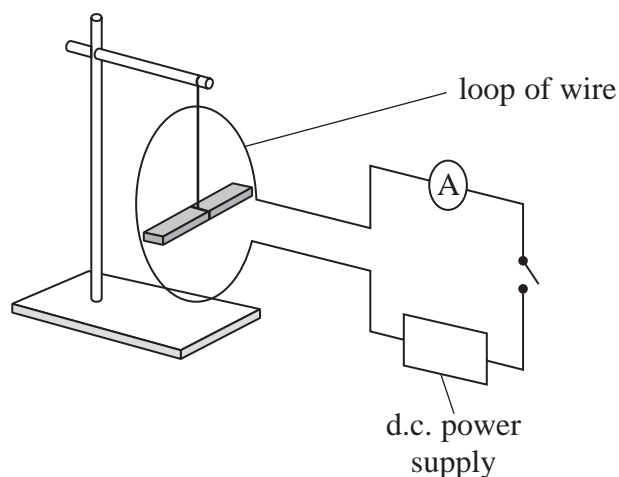
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- (b) A loop of wire was placed vertically around the centre of the oscillating magnet as shown.



When the switch was closed, there was a current  $I$  in the loop of wire and the time period  $T$  of the oscillations decreased.

A student predicted that the relationship between  $T$  and  $I$  is

$$T = I^n$$

where  $n$  is a constant.

- (i) State an additional component required in the circuit that would allow this relationship to be investigated.

(1)

- (ii) Explain why plotting a graph of  $\log T$  against  $\log I$  would test the validity of this relationship.

(2)



(c) The student processed his results and produced the table below.

$T/s$	$I/A$		
0.813	1.20		
0.754	1.40		
0.706	1.60		
0.663	1.80		
0.631	2.00		
0.593	2.20		

- (i) Plot a graph of  $\log T$  against  $\log I$  on the grid opposite.  
Use the additional columns in the table to record your processed data. (6)
- (ii) Use your graph to determine a value for  $n$ . (3)

$n = \dots\dots\dots$

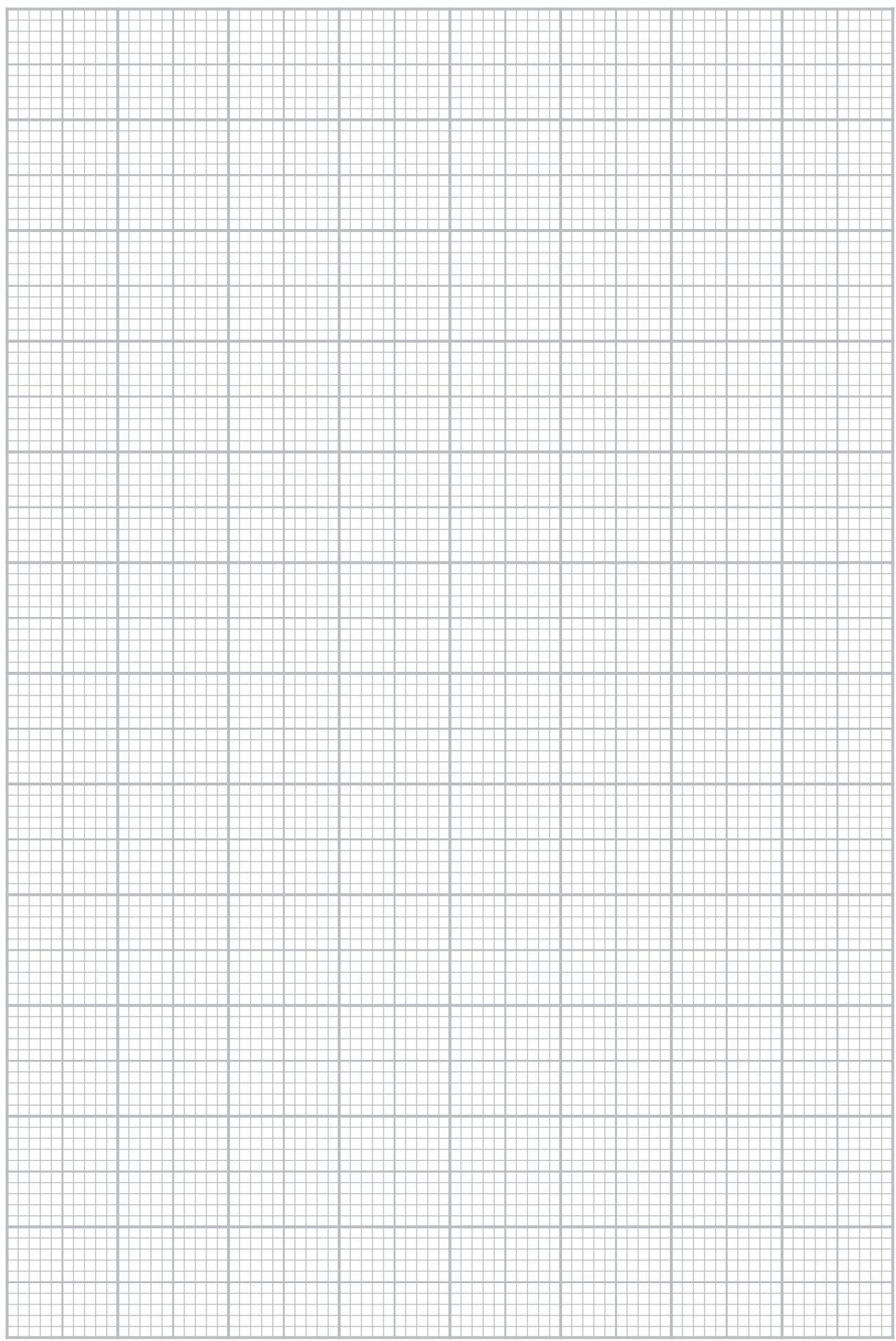




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- (iii) After plotting the graph, the student modified his prediction. He suggested that the relationship between  $T$  and  $I$  is

$$T = kI^n$$

where  $k$  is a constant.

Justify this suggestion.

(4)

(Total for Question 3 = 19 marks)

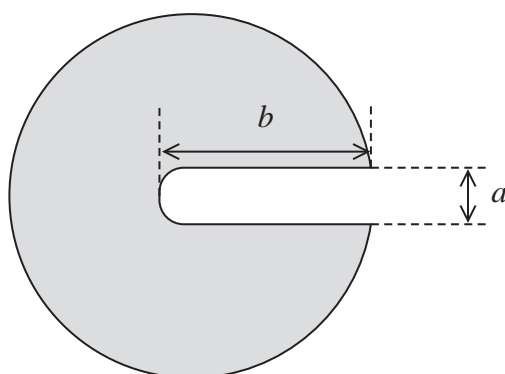
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- 4 The diagram shows a 100 g slotted mass drawn approximately to size. A student determined the density of the metal from which the slotted mass was made.



- (a) (i) State the most appropriate measuring instrument for the student to use to measure the width  $a$  and the length  $b$  of the slot.

(1)

- (ii) Explain one technique she should use when measuring  $a$  and  $b$ .

(2)

- (iii) Calculate the area of the slot and its uncertainty in  $\text{cm}^2$ . Assume the slot is rectangular.

$$a = 0.47 \pm 0.01 \text{ cm}$$

$$b = 2.19 \pm 0.005 \text{ cm}$$

(3)

Area of the slot = .....  $\pm$  .....  $\text{cm}^2$



(b) The student made a single measurement of the diameter of the slotted mass as 3.81 cm.

(i) Calculate the shaded area of the slotted mass in  $\text{cm}^2$ .

(2)

Shaded area = .....  $\text{cm}^2$

(ii) Calculate the uncertainty in the value of the shaded area.

(3)

Uncertainty = .....  $\text{cm}^2$

(c) The student used a micrometer screw gauge to measure the thickness  $t$  of the slotted mass. She obtained the following results.

$t/\text{mm}$				mean $t/\text{mm}$
11.39	11.36	11.35	11.38	11.37

(i) Calculate the density  $\rho$  of the metal in  $\text{g cm}^{-3}$ . Assume the value of mass is 100 g with negligible uncertainty.

(2)

$\rho = \dots\dots\dots \text{g cm}^{-3}$



(ii) Calculate the percentage uncertainty in the value of  $\rho$ .

(3)

Percentage uncertainty = .....

(d) The student thinks that the slotted mass is made from brass, which has a density of  $8.5 \text{ g cm}^{-3}$ .

Determine whether the slotted mass could be made of brass.

(2)

(Total for Question 4 = 18 marks)

**TOTAL FOR PAPER = 50 MARKS**

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### List of data, formulae and relationships

Acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\epsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19} \text{ C}$	
Electron mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27} \text{ kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27} \text{ kg}$	

#### Unit 1

##### Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{\text{grav}} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

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Efficiency

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

*Materials*

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$$F = 6\pi\eta rv$$

Hooke's law

$$\Delta F = k\Delta x$$

Elastic strain energy

$$\Delta E_{\text{el}} = \frac{1}{2} F\Delta x$$

Young modulus

$$E = \frac{\sigma}{\varepsilon} \text{ where}$$

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

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**Unit 2****Waves**

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\frac{T}{\mu}}$
Intensity of radiation	$I = \frac{P}{A}$
Refractive index	$n_1 \sin \theta_1 = n_2 \sin \theta_2$ $n = \frac{c}{v}$
Critical angle	$\sin C = \frac{1}{n}$
Diffraction grating	$n\lambda = d \sin \theta$

**Electricity**

Potential difference	$V = \frac{W}{Q}$
Resistance	$R = \frac{V}{I}$
Electrical power, energy	$P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$ $W = VIt$
Resistivity	$R = \frac{\rho l}{A}$
Current	$I = \frac{\Delta Q}{\Delta t}$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

**Quantum physics**

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv_{\max}^2$
de Broglie wavelength	$\lambda = \frac{h}{p}$

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**Unit 4***Mechanics*

Impulse

$$F\Delta t = \Delta p$$

Kinetic energy of a  
non-relativistic particle

$$E_k = \frac{p^2}{2m}$$

motion in a circle

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

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

Centripetal force

$$F = ma = \frac{mv^2}{r}$$

$$F = m\omega^2 r$$

*Electric and magnetic fields*

Electric field

$$E = \frac{F}{Q}$$

Coulomb's law

$$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$$

$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$E = \frac{V}{d}$$

Electrical Potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

Capacitance

$$C = \frac{Q}{V}$$

Energy stored in capacitor

$$W = \frac{1}{2} QV$$

$$W = \frac{1}{2} CV^2$$

$$W = \frac{1}{2} \frac{Q^2}{C}$$

Capacitor discharge

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

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Resistor capacitor discharge

$$I = I_0 e^{-t/RC}$$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field

$$F = Bqv \sin \theta$$

$$F = BIl \sin \theta$$

Faraday's and Lenz's laws

$$\mathcal{E} = \frac{-d(N\phi)}{dt}$$

*Nuclear and particle physics*

In a magnetic field

$$r = \frac{p}{BQ}$$

Mass-energy

$$\Delta E = c^2 \Delta m$$

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**Unit 5***Thermodynamics*

Heating  $\Delta E = mc\Delta\theta$

$$\Delta E = L\Delta m$$

Ideal gas equation  $pV = NkT$

Molecular kinetic theory  $\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$

*Nuclear decay*

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

Radio-active decay  $A = -\lambda N$

$$\frac{dN}{dt} = -\lambda N$$

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

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

$$A = A_0 e^{-\lambda t}$$

*Oscillations*

Simple harmonic motion  $F = kx$

$$a = -\omega^2 x$$

$$x = A \cos \omega t$$

$$v = -A\omega \sin \omega t$$

$$a = A\omega^2 \cos \omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$T = 2\pi \sqrt{\frac{l}{g}}$$

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*Astrophysics and Cosmology*

Gravitational field strength  $g = F/m$

Gravitational force  $F = \frac{Gm_1m_2}{r^2}$

Gravitational field  $g = \frac{Gm}{r^2}$

Gravitational potential  $V_{grav} = \frac{-Gm}{r}$

Stephan-Boltzman law  $L = \sigma T^4 A$

Wein's law  $\lambda_{max} T = 2.898 \times 10^{-3} \text{ m K}$

Intensity of radiation  $I = \frac{L}{4\pi d^2}$

Redshift of electromagnetic radiation  $z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$

Cosmological expansion  $v = H_0 d$

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