2021-DSE
PHY
PAPER 1A

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2021

PHYSICS PAPER 1

8:30 am – 11:00 am (2½ hours)
This paper must be answered in English

GENERAL INSTRUCTIONS

(1) There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 50 minutes.

(2) Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book **B**.

(3) Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in the Question-Answer Book. **The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.**

(4) The diagrams in this paper are **NOT** necessarily drawn to scale.

(5) The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

(1) Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first stick a barcode label and insert the information required in the spaces provided. No extra time will be given for sticking on the barcode label after the 'Time is up' announcement.

(2) When told to open this book, you should check that all the questions are there. Look for the words **'END OF SECTION A'** after the last question.

(3) All questions carry equal marks.

(4) **ANSWER ALL QUESTIONS.** You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.

(5) You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

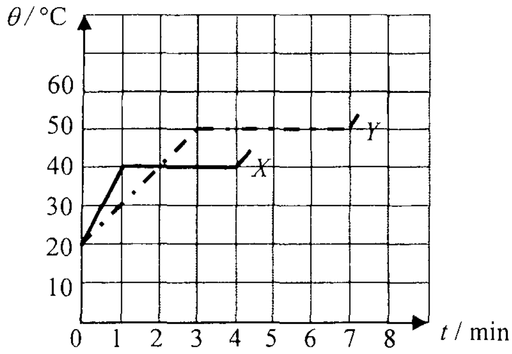
(6) No marks will be deducted for wrong answers.

Not to be taken away before the end of the examination session

Section A

There are 33 questions. Questions marked with * involve knowledge of the extension component.

1. Solid substances X and Y of equal mass are heated by heaters of power $2P$ and P respectively. The graph shows how the temperature θ of each substance varies with the heating time t.



What is the ratio of the specific latent heat of fusion of X to that of Y ?

A. 3 : 2
B. 3 : 4
C. 4 : 3
D. 2 : 3

2. Metal blocks X and Y are identical in size and shape. X is of a higher temperature than Y. Which of the following statements must be correct ?

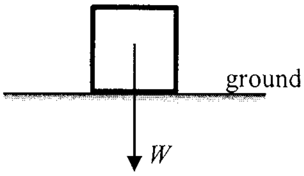
(1) Energy will flow from X to Y if they are in thermal contact.
(2) X is a better conductor of heat compared to Y.
(3) The total internal energy of X is higher than that of Y.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

*3. For an ideal gas, kinetic theory deduces that $pV = \frac{1}{3}Nm\overline{c^2}$. Which physical quantity below can be represented by $\frac{3p}{\overline{c^2}}$?

A. the total mass of the gas
B. the volume of one mole of the gas
C. the density of the gas
D. the number of gas molecules per unit volume

4. A block of weight W is at rest on a horizontal ground as shown.



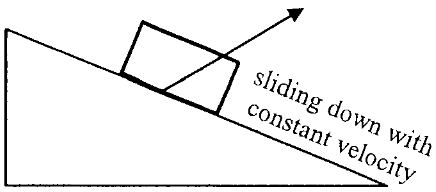
The force acting on the block by the ground is R. Which of the following statements is/are correct ?

(1) R and W are opposite in direction.
(2) R and W are equal in magnitude.
(3) R and W is an action-and-reaction pair.

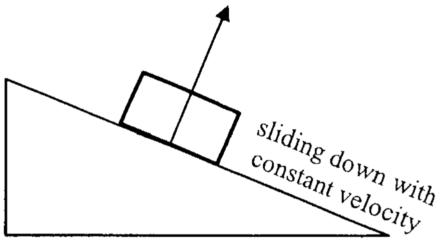
A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

5. A block is sliding down a rough incline with constant velocity as shown. Which arrow indicates the direction of **the resultant force acting on the block by the incline** ? Neglect air resistance.

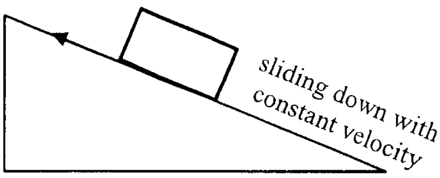
A.



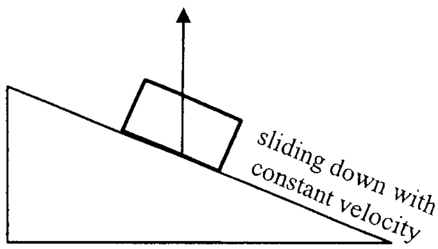
B.



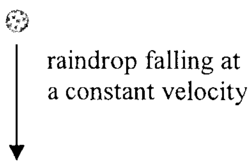
C.



D.

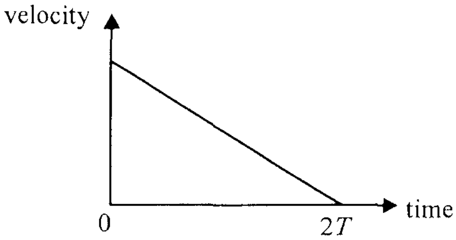


6. Which statement below about a raindrop falling at a constant terminal velocity is correct ?



A. No work is done on the raindrop by the gravitational force.
B. As the raindrop falls, all its gravitational potential energy loss is converted into kinetic energy gain.
C. The only force acting on the raindrop is its weight.
D. No net force is acting on the raindrop.

7. At time $t = 0$, a small sphere is projected up along a smooth incline with a certain initial velocity. It travels a distance L and becomes momentarily at rest after a time $2T$. The corresponding velocity-time graph is shown below.



What is the distance travelled by the sphere from $t = 0$ to $t = T$?

A. $\frac{1}{4}L$

B. $\frac{1}{2}L$

C. $\frac{3}{4}L$

D. $\frac{4}{5}L$

8. A stationary uranium nucleus ${}^{238}_{92}\text{U}$ decays to give a thorium nucleus ${}^{234}_{90}\text{Th}$ and an α particle ${}^{4}_{2}\text{He}$.

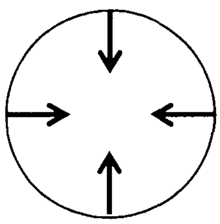
$$ {}^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He} $$

Which of the following correctly describes the situation about the ${}^{234}_{90}\text{Th}$ nucleus and the α particle just after the decay ?

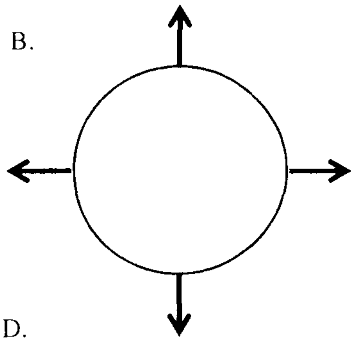
	magnitude of momentum p	kinetic energy KE
A.	$p(\text{Th}) = p(\alpha)$	$\text{KE(Th)} < \text{KE}(\alpha)$
B.	$p(\text{Th}) > p(\alpha)$	$\text{KE(Th)} > \text{KE}(\alpha)$
C.	$p(\text{Th}) = p(\alpha)$	$\text{KE(Th)} > \text{KE}(\alpha)$
D.	$p(\text{Th}) = p(\alpha)$	$\text{KE(Th)} = \text{KE}(\alpha)$

*9. A particle is moving clockwise (top view) in a horizontal circle with uniform speed. Which top view diagram below correctly shows the net force acting on the particle at various positions ?

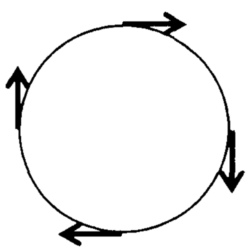
A.



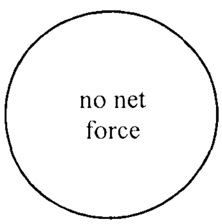
B.



C.



D.

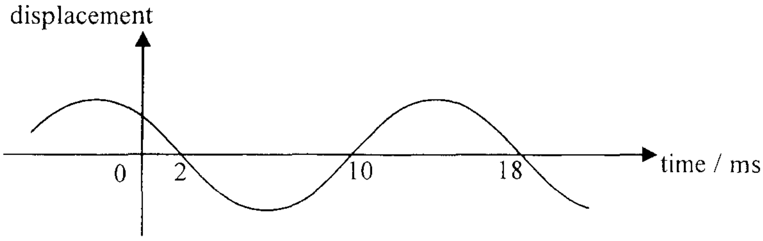


10. Which of the following can be transferred by mechanical waves from one place to another along the direction of propagation ?

(1) mass
(2) momentum
(3) energy

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

11.



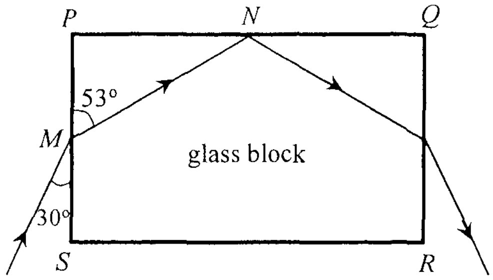
The displacement-time graph of a particle on a travelling wave is as shown. Find the frequency of the wave.

A. 55.6 Hz
B. 62.5 Hz
C. 111 Hz
D. 125 Hz

12. Earthquakes propagate in the form of waves. The quake centre produces both longitudinal waves (P-wave) and transverse waves (S-wave) which travel with speeds 9.6 km s^{-1} and 6.4 km s^{-1} respectively on the Earth's crust. In an earthquake, a monitoring station detects the arrival of the P-wave pulse at 7:02 a.m. while the S-wave pulse arrives 2 minutes later at 7:04 a.m. Estimate the time that this earthquake occurs.

A. 6:53 a.m.
B. 6:56 a.m.
C. 6:58 a.m.
D. 6:59 a.m.

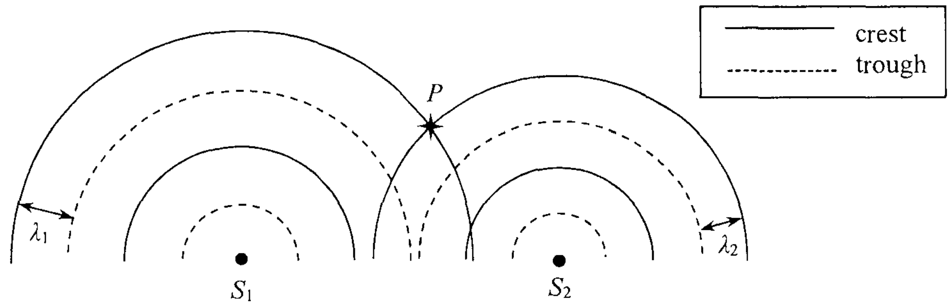
13.



The figure shows the cross-section of a rectangular glass block *PQRS*. A light ray is incident from air at *M* on face *PS* and the refracted ray strikes face *PQ* at *N*. Find the critical angle for the glass-air interface.

A. 37°
B. 44°
C. 53°
D. 60°

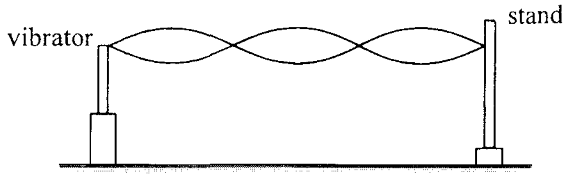
14. In a ripple tank, circular water waves of wavelengths λ_1 and λ_2 ($\lambda_1 > \lambda_2$) are produced by two vibrators S_1 and S_2 respectively. The figure represents the two circular waves propagating on the water surface at a certain moment.



Which of the following statements is correct ?

A. The particle at *P* is always at crest position.
B. At *P*, the two waves always reinforce to give a larger amplitude.
C. The principle of superposition cannot be applied at *P* as $\lambda_1 \neq \lambda_2$.
D. The principle of superposition can be applied at *P* but the two waves do not always reinforce at that location.

15. In the set-up below, different stationary wave patterns are formed on an elastic string by adjusting the frequency f of the vibrator.

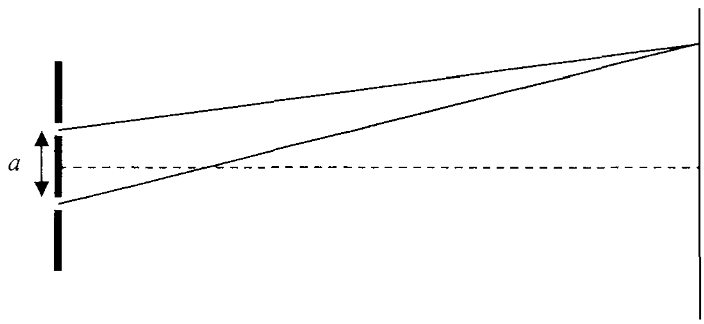


Which statements are correct when f increases ?

(1) The number of antinodes increases.
(2) The speed of the waves on the string increases.
(3) The frequency of the waves produced in air by the string increases.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

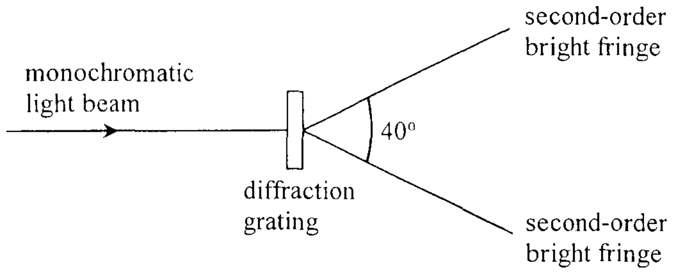
16. In Young's double slit experiment employing monochromatic light, how will the interference pattern change if the separation a of the double slit is reduced ?



(1) The pattern will become brighter.
(2) The number of fringes that can be observed will increase.
(3) The fringe separation of the pattern will become larger.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

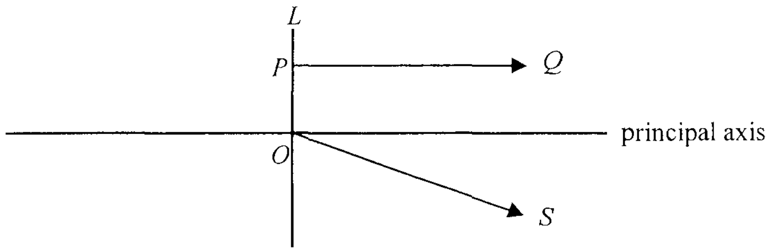
*17.



When a monochromatic light beam is incident normally on a diffraction grating with 300 lines per mm, a pattern of bright fringes is formed. The angle between the two second-order bright fringes is 40°. Find the frequency of the light.

A. 1.4×10^{14} Hz
B. 2.6×10^{14} Hz
C. 2.8×10^{14} Hz
D. 5.3×10^{14} Hz

18. In the figure below, PQ and OS are light rays refracted from a lens L. Both light rays come from a point object situated on the left of L.



Which of the following deductions is/are correct ?

(1) The image of the object must be virtual.
(2) The object must lie along the straight line containing OS.
(3) L must be a concave lens.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

19. Typical wavelengths of X-rays and microwaves are in the ratio $10^n : 1$. The value of n could be

A. −10.
B. −4.
C. +4.
D. +10.

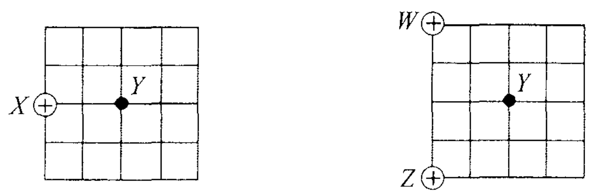
20. Submarines employ ultrasound instead of microwaves to detect obstacles in the sea. This is because

A. wavelengths of ultrasound are shorter than those of microwaves.
B. ultrasound travels faster than microwaves in the sea.
C. microwaves are easily absorbed by sea water.
D. microwaves diffract too much in the sea.

21. Three isolated identical metal spheres X, Y and Z carry charges $+2Q$, $-4Q$ and $+5Q$ respectively. Y is first moved to touch X and then Y is brought in contact with Z. When Y and Z are separated, find the charge on each sphere.

	X	Y	Z
A.	0	$+1.5Q$	$+1.5Q$
B.	$-Q$	$+0.5Q$	$+0.5Q$
C.	$+Q$	$+Q$	$+Q$
D.	$-Q$	$+2Q$	$+2Q$

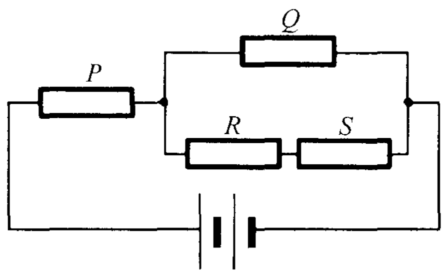
*22. When a point charge $+Q$ is placed at X as shown, the strength of the electric field at Y is E_0.



If W and Z are each placed with a point charge of $+Q$, what will be the electric field strength at Y ?
Note: $\sin 45° = \cos 45° = \frac{\sqrt{2}}{2}$

A. $\frac{\sqrt{2}}{2} E_0$
B. E_0
C. $\sqrt{2} E_0$
D. $2 E_0$

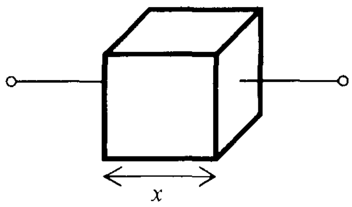
23. Four identical resistors P, Q, R and S are connected to a battery of negligible internal resistance as shown.



If the power dissipated by R is 1 W, find the total power output of the battery.

A. 11 W
B. 15 W
C. 19 W
D. 21 W

24. The figure shows a metallic cube of side length x. How is its resistance R between any two opposite faces related to x ?



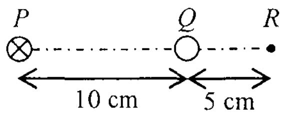
A. $R \propto \frac{1}{x}$

B. $R \propto x$

C. $R \propto x^2$

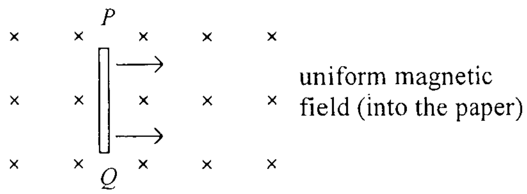
D. $R \propto \frac{1}{x^2}$

25. In the figure below, PQR is a straight line with $PQ = 10$ cm and $QR = 5$ cm. A long straight wire carrying a current of 0.3 A (directed into the paper) is placed at P. When another long straight wire carrying a current I is placed at Q, the resultant magnetic field at R becomes zero. Determine the direction and magnitude of I.



	direction of I	magnitude of I
A.	into the paper	0.1 A
B.	into the paper	0.9 A
C.	out of the paper	0.1 A
D.	out of the paper	0.9 A

26. When a copper rod PQ moves with a constant velocity across a uniform magnetic field as shown, an e.m.f. is induced across the rod.

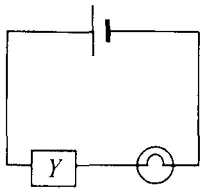


Which of the following statements is/are correct ?

(1) The magnitude of the induced e.m.f. depends on the length of the rod.
(2) Rod PQ acts like a cell providing an e.m.f. with P being its positive terminal.
(3) There is a force acting on the rod to oppose its motion.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

27. A light bulb is connected in series with a device Y and a cell as shown. Assume that the internal resistance of the cell is negligible and its e.m.f. remains unchanged.

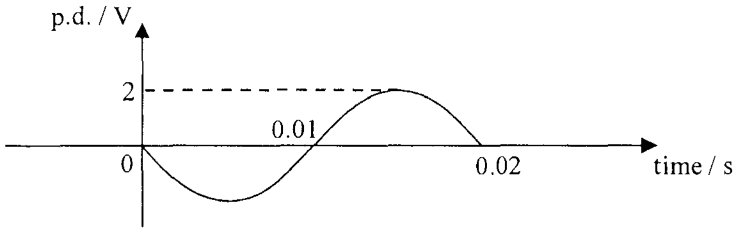


It is found that the brightness of the light bulb decreases with time. Which deductions must be correct ?

(1) The current in Y decreases with time.
(2) The voltage across Y decreases with time.
(3) The power supplied by the cell decreases with time.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

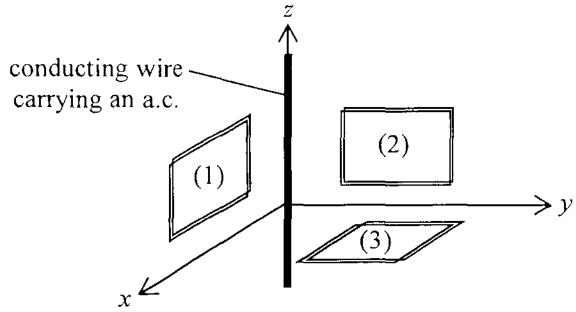
*28. The graph shows the waveform of a sinusoidal alternating p.d. applied across a 10 Ω resistor.



Find the root-mean-square current in this 10 Ω resistor and the average power dissipated by it.

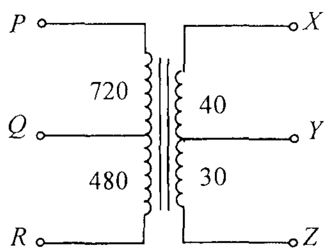
	root-mean-square current / A	average power / W
A.	0.14	0.2
B.	0.14	0.4
C.	0.2	0.2
D.	0.2	0.4

29. The figure shows three mutually perpendicular coils (1), (2) and (3) placed near a conducting wire carrying an a.c. along the z-axis direction. In which coil(s) would e.m.f. be induced ?



A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

*30.



The above figure represents a multi-tapped transformer. The number of turns between the various 'tapping points' are indicated as shown. Which connections should be used for stepping down a voltage from 240 V to 6 V ?

	primary coil	secondary coil
A.	*PQ*	*XY*
B.	*PQ*	*YZ*
C.	*PR*	*XY*
D.	*PR*	*YZ*

31. A radioactive nuclide plutonium-239 ($^{239}_{94}Pu$) becomes a stable lead-207 isotope ($^{207}_{82}Pb$) after a series of α and β decays. Find the number of β decays in the process.

A. 3
B. 4
C. 5
D. 6

32. The activity of a radioactive sample is measured to be 18 MBq. What is its activity 3 half-lives before ?

A. 6 MBq
B. 54 MBq
C. 72 MBq
D. 144 MBq

33. Which of the following may contain sources of ionizing radiations ?

(1) sea water
(2) a rock sample
(3) human body

A. (1) only
B. (2) only
C. (2) and (3) only
D. (1), (2) and (3)

END OF SECTION A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$	
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$	
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)	
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$	
charge of electron	$q_e = 1.60 \times 10^{-19}\ \text{C}$	
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$	
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$	
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$	(1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$	
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$	
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$	
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	

Rectilinear motion

For uniformly accelerated motion :

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

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

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

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}{}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e q_e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling
A2.	$E = l\,\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy

B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2.	moment $= F \times d$	moment of a force
B3.	$E_P = mgh$	gravitational potential energy
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation

C1.	$\Delta y = \frac{\lambda D}{a}$	fringe separation in double-slit interference
C2.	$d\sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens

D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2R$	power in a circuit
D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer

E1.	$N = N_0 e^{-kt}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$\Delta E = \Delta mc^2$	mass-energy relationship