F.6 MOCK EXAMINATION 2020 – 21

PHYSICS PAPER 1

4th February 2021

8.25 am – 10.55 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 write your Candidate number in the spaces provided. No extra time will be given for writing Candidate number 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.

Section A

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

1. Some hot water of mass $2M$ is mixed with cold water of mass M. If the temperatures of the hot water and cold water before mixing are $2T$ and T respectively, what is the final temperature of the mixture?

A. $\frac{2}{3}T$
B. $\frac{2}{5}T$
C. $\frac{4}{3}T$
D. $\frac{5}{3}T$

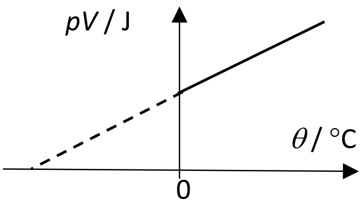
2. The temperature of a hot liquid in a container falls at a rate of 2 K per minute just before it begins to solidify. The temperature then remains steady for 20 minutes by which time all the liquid has solidified. What is the quantity $\frac{\text{specific heat capacity of the liquid}}{\text{specific latent heat of fusion of the lquid}}$?

A. $\frac{1}{40}$ K^{-1}
B. $\frac{1}{10}$ K^{-1}
C. 10 K^{-1}
D. 40 K^{-1}

*3. A fixed mass of gas occupies a volume V. The temperature of the gas increases so that the root mean square speed of the gas molecules is doubled. What will the new volume be if the pressure remains constant?

A. $\frac{V}{2}$
B. $\frac{V}{\sqrt{2}}$
C. $2V$
D. $4V$

*4. The graph shows the relation between the product pressure × volume, pV, and temperature, θ, in degrees Celsius for 1 mol of an ideal gas. The universal gas constant is R. Which one of the following expressions gives the gradient of this graph?



A. $\frac{1}{273}$
B. $\frac{pV}{\theta}$
C. $\frac{pV}{\theta - 273}$
D. R

5. Which of the following statement(s) concerning the motion of a body is/are correct?

(1) When a body has a non-zero acceleration, its velocity must be non-zero.
(2) The average speed of a body cannot be less than the magnitude of its average velocity.
(3) When a body moves at a constant speed, its acceleration must be zero.

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

6. A block is placed on a rough plank. The plank is placed on a smooth ground and attached to a string fixed to a wall as shown in Figure a. A horizontal force F is applied on the block. The minimum value of F to set the block into motion is 20 N. If F increases with time t as shown in Figure b, which of the following graphs correctly shows the variation of tension T in the string with time?

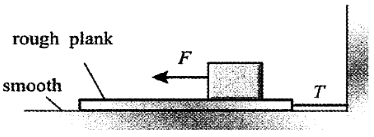


Figure a

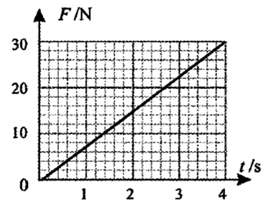
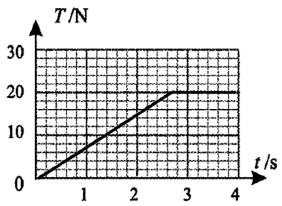
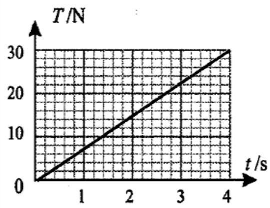


Figure b

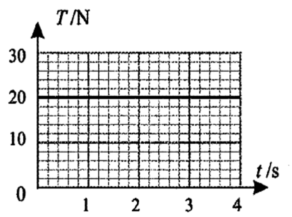
A.



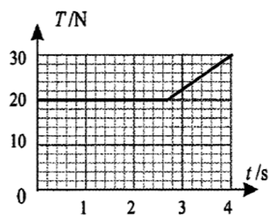
B.



C.



D.

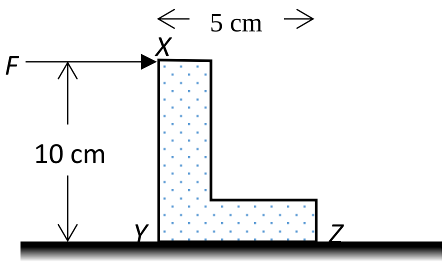


7. Two blocks A and B, of masses 8 kg and 5 kg respectively, are connected by a light inextensible string. The string passes over a smooth pulley of negligible mass which is connected to a spring balance fixed to the ceiling as shown. The blocks are then released. Which of the following statements are correct?

(1) The tensions acting on the two blocks are the same.
(2) The two blocks move with the same speed and acceleration.
(3) The reading of the spring balance is 121 N after the blocks have been released.

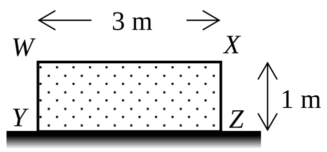
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

8. An L-shape block XYZ of weight 40 N rests on a rough horizontal surface. The lengths of XY and YZ are 10 cm and 5 cm respectively. When a horizontal force F is applied to it at X as shown, the block just overturns when F equals 12 N. If F is applied to the block at X in the opposite direction, what is its minimum value to overturn the block?



A. 6 N
B. 8 N
C. 12 N
D. Cannot be determined because the position of the centre of gravity is not given.

9. A 10 kg rectangular block *WXYZ* of uniform density is placed on a table. The lengths of *WX* and *XZ* are 3 m and 1 m respectively. Find the minimum energy needed to rotate the block so that *XZ* is in contact with the table.



A. 98.1 J
B. 106 J
C. 196 J
D. 212 J

10. A sphere moves at a speed of 1 m s^{-1} towards a spring fixed to a wall. After hitting the spring, the sphere slows down. It is instantaneously at rest when the spring is compressed the most. Which of the following statements about the momentum of the sphere are **INCORRECT**?

(1) It is stored as elastic potential energy in the spring when the sphere is at rest.
(2) It is conserved only if there is no energy lost to surroundings.
(3) If the sphere leaves the spring at the speed of 1 m s^{-1}, its momentum is conserved.

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

*11. A boy jumps vertically upwards on a train moving horizontally at a constant velocity, where will the boy land on the train? Neglect air resistance.

A. In front of the spot he jumps
B. At the same spot he jumps
C. Behind the spot he jumps
D. Cannot be determined because the motion direction of the train is not given.

*12. A person is spinning her umbrella at a constant angular speed to dry it. Which of the following statements about the raindrops on the umbrella is/are correct?

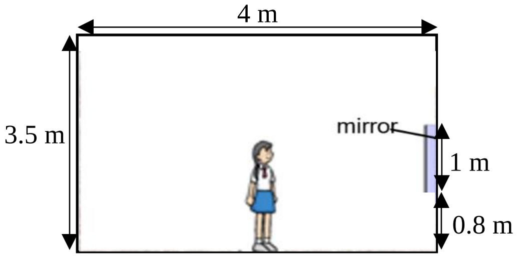
(1) Those further away from the centre are more likely to leave the umbrella.
(2) They leave the umbrella radially from the centre.
(3) They leave the umbrella when the forces pushing them away are large enough.

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

*13. *X* and *Y* are two planets. Each of them has a low-altitude satellite revolving in a circular orbit close to its surface. If the two satellites, are observed to have the same orbital period, which of the following can be deduced?

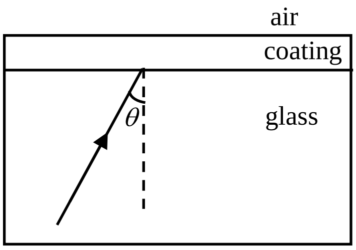
A. *X* and *Y* have the same mass.
B. *X* and *Y* have the same radius.
C. *X* and *Y* have the same average density.
D. Nothing can be deduced.

14. A plane mirror of 1 m high is fixed 0.8 m above the floor on a wall of a room as shown. A girl stands in front of the mirror and can **just** see the whole image of the wall behind her in the mirror. What is the girl's eye level above the floor?



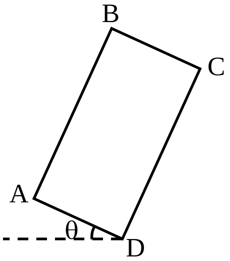
A. 1.03 m
B. 1.12 m
C. 1.40 m
D. Cannot be determined since the separation between the girl and the mirror is unknown.

15. A glass block of refractive index 1.5 is covered with a uniform layer of coating. A light ray is incident on the glass-coating interface with an angle of θ. Given the refractive index of the coating is 1.2, what is the range of θ for the light ray to be totally reflected at the air-coating interface?



A. $\theta > 56.4°$
B. $56.4° > \theta > 53.1°$
C. $56.4° > \theta > 41.8°$
D. $53.1° > \theta > 41.8°$

16. A horizontal light ray travels in air and strikes the side *AB* of a rectangular glass block *ABCD*. The refractive index of the glass block is 1.5 and the side *AD* makes an angle of θ with the horizontal. The light ray cannot emerge from the glass block on the side



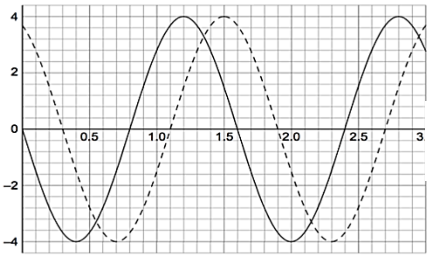
(1) The emergent ray comes out from the side *CD* and is parallel to the incident ray.
(2) When the horizontal incident ray is shifted towards *A*, the emergent ray can come out from the side *AD*.
(3) When the horizontal incident ray is shifted towards *B*, the emergent ray can come out from the side *BC*.

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

*17. A lens L_1 with focal length f is placed in front of a luminous object and its image of linear magnification 3 is formed on a screen which is 40 cm from the object. With the object-screen separation remains unchanged, L_1 is replaced by another lens L_2 such that an image of linear magnification 4 is formed on the screen. The focal length of L_2 is

A. $0.85\,f$
B. $1.10\,f$
C. $1.17\,f$
D. $6.4\,f$

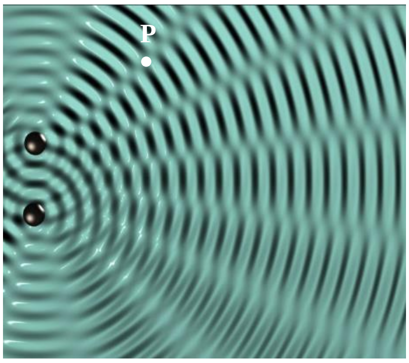
18. The diagram below shows the displacement-distance graph of a travelling wave at $t = 0$ (solid line) and at $t = 0.1$ s (dotted line) respectively. The frequency of the wave could be



(1) 8.125 Hz
(2) 11.875 Hz
(3) 18.125 Hz

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

19. Two dippers vibrate in phase in a ripple tank and an interference pattern formed is shown. The vibrating frequency is 25 Hz and destructive interference occurs at point *P*. Constructive interference will occur at point *P* if the dippers vibrate at



(1) 30 Hz
(2) 50 Hz
(3) 62.5 Hz

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

20. The refractive index of water 1.33 and the visible light spectrum has a frequency range from 4.05×10^{14} Hz to 7.90×10^{14} Hz. Estimate the wavelength of violet light in water.

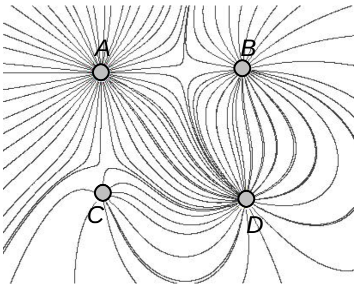
A. 557 nm
B. 380 nm
C. 285 nm
D. 253 nm

21. Which of the following statements about sound wave is/are correct?

(1) The sound intensity level describes the loudness of a sound.
(2) When a sound wave travels from air into water, its speed increases.
(3) Humans can hear sound waves of all frequency lower than 20 kHz.

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

22. The figure below shows an electric field pattern produced by four charged particles. Which of the particles carries a charge with a sign opposite to those of the other three?

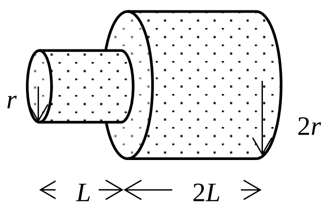


D

23. Two identical tiny conducting spheres *A* and *B* are fixed and are separated by a certain distance. Sphere *A* carries half the amount of charge carried by sphere *B* and the spheres experience mutual repulsive electric force of magnitude *F*. Now an identical but insulated neutral conducting sphere *C* touches *A*, then touches *B* and is finally removed. Find the new magnitude of the electric force experienced by *A* and *B* in terms of *F*.

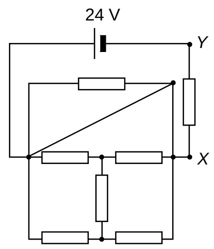
A. $\frac{5F}{32}$
B. $\frac{5F}{16}$
C. $\frac{5F}{8}$
D. $\frac{5F}{4}$

24. A copper wire of length *L* and radius *r* has a resistance of *R*. If it is connected to another copper wire of length 2*L* and radius 2*r* as shown, the total resistance of the connected wire is



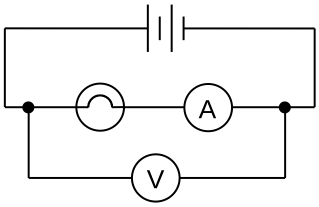
A. $\frac{R}{3}$
B. R
C. $1.5R$
D. $3R$

25. The circuit below consists of seven 2 Ω resistors and a 24 V battery. What is the potential difference across *XY*?



A. 2 V
B. 3.43 V
C. 12 V
D. 24 V

26. A student connects a circuit as shown below. The internal resistance of the battery, the ammeter and the voltmeter CANNOT be neglected.

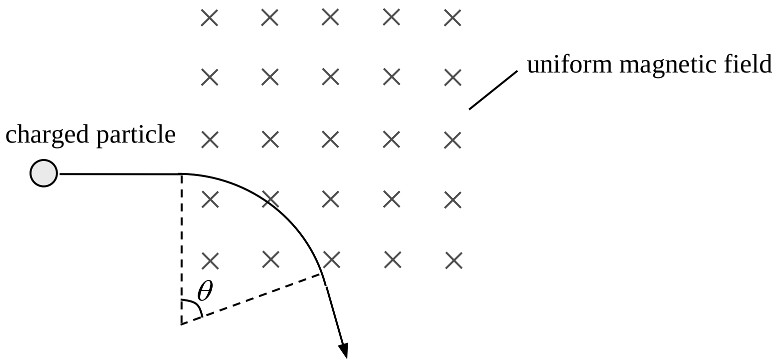


Which of the following statements are **INCORRECT**?

(1) The ammeter reading equals the current passing through the light bulb and that through the battery.
(2) The voltmeter reading is larger than the potential difference across the bulb but is equal to the emf of the battery.
(3) The connection is suitable for measuring the resistance of the bulb if its resistance is high.

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

*27. A charged particle enters a uniform magnetic field of 1.5×10^{-6} T and leaves the field after 0.01 s. The particle moves in a circular arc within the magnetic field, as shown below.



The charge of the particle is 3.2×10^{-19} C and its mass is 3.4×10^{-27} kg. Find the angular displacement θ of the particle in passing the field.

A. 0.2 rad
B. 0.8 rad
C. 1.1 rad
D. 1.4 rad

*28. Which of the following are equivalent to the unit of magnetic flux？

(1) T m^2
(2) N m C^{-1} s
(3) V s

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

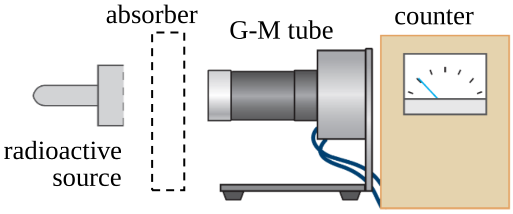
*29. A transformer works at an efficiency of 80%. The primary voltage is 100 V and the turns ratio $n_p : n_s$ is 20 : 1. If the resistance of the secondary circuit is 50 Ω, what is the primary current?

A. 5 mA
B. 6.25 mA
C. 10 mA
D. 2 A

30. Which of the following statements about ionizing radiation is correct?

A. The ionizing power of α-particles is much weaker than that of β-particles.
B. γ-radiation can be completely shielded by a 10 cm thick concrete wall.
C. Ionizing radiation α and β undergo deflection in a magnetic field.
D. γ-radiation produces straight and thick tracks in a diffusion cloud chamber.

31. A student puts a radioactive source very close to a G-M tube. Then he puts different absorbers between them in turn.



He records the count rate for each absorber in the table below.

Absorber	Count rate / min^{-1}
–	328
A sheet of paper	*X*
5 mm aluminium	*Y*
25 mm lead	*Z*
50 mm lead	50

If the radioactive source emits only α and γ radiation, which of the following is most likely to be the values of *X*, *Y* and *Z*?

	X	*Y*	*Z*
A.	320	147	53
B.	320	85	71
C.	147	138	85
D.	147	85	53

32. Which of the following best describes the decay constant for a radioisotope?

A. The reciprocal of the half-life of the radioisotope.
B. The rate of decay of the radioisotope.
C. The constant of proportionality which links half-life to the rate of decay of nuclei.
D. The constant of proportionality which links rate of decay to the number of undecayed nuclei.

*33. The reaction shown below occurs when a proton and a deuterium nucleus, ${}^{2}_{1}H$, fuse to form a helium nucleus, ${}^{3}_{2}He$.

$${}^{1}_{1}p + {}^{2}_{1}H \rightarrow {}^{3}_{2}He$$

If the energy released in the reaction is 5.49 MeV, what is the mass of the helium nucleus? (mass of ${}^{2}_{1}H$ nucleus = 2.01355 u; mass of proton = 1.00728 u)

A. 0.00590 u
B. 3.01493 u
C. 3.02083 u
D. 3.02323 u

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	$e = 1.60 \times 10^{-19}\ \text{C}$
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		**Energy and Use of Energy**	
$U = -\frac{GMm}{r}$	gravitational potential energy	$E = \frac{\Phi}{A}$	illuminance
$P = \sigma AT^4$	Stefan's law	$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	Doppler effect	$U = \frac{\kappa}{d}$	thermal transmittance U-value
		$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine
Atomic World		**Medical Physics**	
$\frac{1}{2}m_e v_{max}{}^2 = hf - \phi$	Einstein's photoelectric equation	$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	energy level equation for hydrogen atom	power $= \frac{1}{f}$	power of a lens
		$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula	$Z = \rho c$	acoustic impedance
		$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)	$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling	D1.	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\,\Delta m$	energy transfer during change of state	D2.	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \dfrac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \dfrac{1}{3}Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \dfrac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \dfrac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$	resistors in parallel
B1.	$F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2R$	power in a circuit
B2.	moment $= F \times d$	moment of a force	D8.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \dfrac{1}{2}mv^2$	kinetic energy	D10.	$B = \dfrac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \dfrac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \dfrac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \dfrac{Gm_1m_2}{r^2}$	Newton's law of gravitation	D13.	$\dfrac{V_s}{V_p} \approx \dfrac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
C1.	$\Delta y = \dfrac{\lambda D}{a}$	fringe width in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d\sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \dfrac{\ln 2}{k}$	half-life and decay constant
C3.	$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship