Queen's College

Mock Examination 2021-2022

Physics Paper 1

Secondary 6

Date: 18 February 2022
Time: 8.30 a.m. – 11.00 a.m.
(2.5 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 Question-Answer Book B. **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 examination, write the information required in the spaces provided.

(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.

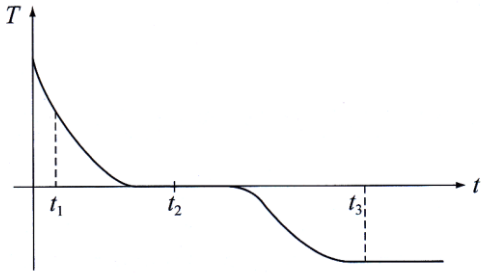
Section A

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

1. A cup of liquid *A* at 20 °C is mixed with a cup of liquid *B* at 100 °C. The masses of two cups of liquid are the same. If the specific heat capacities of A and B are in the ratio 4 : 1, what is the equilibrium temperature of the mixture? Assume that there is no energy loss to the surroundings.

   A. 36 °C
   B. 40 °C
   C. 80 °C
   D. 84 °C

2. Some water is put into a freezer. The graph shows how the temperature *T* of water varies with time *t*.



   Which of the following statements is/are correct?

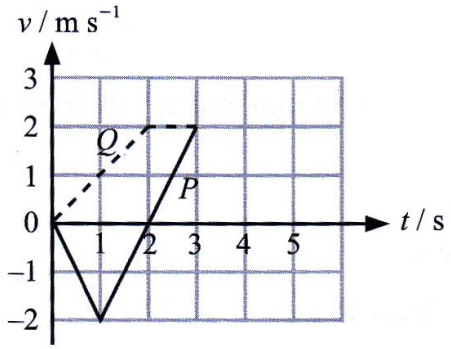
   (1) At $t = t_1$, both the average kinetic energy and intermolecular potential energy of the water molecules are decreasing.
   (2) At $t = t_2$, only the intermolecular potential energy of the water molecules is decreasing.
   (3) At $t = t_3$, both the average kinetic energy and the intermolecular potential energy of the water molecules remain unchanged.

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

* 3. Two different gases *X* and *Y* are contained in two identical vessels. If the ratio of their molecular masses is 4 : 1 and the ratio of their absolute temperatures are 3 : 1, find the ratio of their root-mean-square molecular speeds.

   A. $2 : \sqrt{3}$
   B. $\sqrt{3} : 2$
   C. 3 : 4
   D. 4 : 3

4. Two particles P and Q start from the same position and travel along the same straight line. Their velocity-time graph is shown below.



Which of the following statements is/are correct?

(1) At t = 1 s, P changes its direction of motion.

(2) At t = 2 s, the distances travelled by P and Q are the same.

(3) At t = 3 s, the separation between P and Q is the largest.

A. (1) only

B. (2) only

C. (1) and (3) only

D. (2) and (3) only

5. Two 8 N forces act on the same point of an object. What should be the angle between the two forces if the resultant force is also 8 N in magnitude?

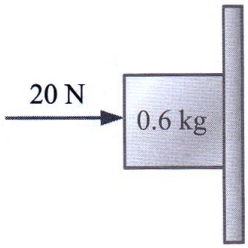
A. 30°

B. 45°

C. 60°

D. 120°

6. A block of mass 0.6 kg is pressed against a wall by a horizontal force of 20 N as shown. The maximum friction between the wall and the block is 0.4 times the normal reaction.



Find the magnitude of the acceleration of the block.

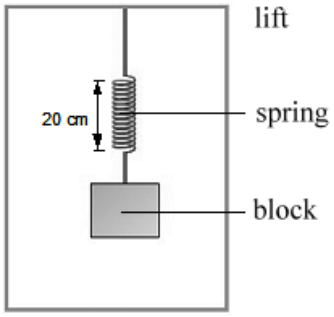
A. 0

B. 3.52 m s^{-2}

C. 9.81 m s^{-2}

D. 16.6 m s^{-2}

7. A block is suspended from a spring in a lift as shown. When the lift is at rest, the spring has a length of 20 cm.



What is the length of the spring in the following situations?

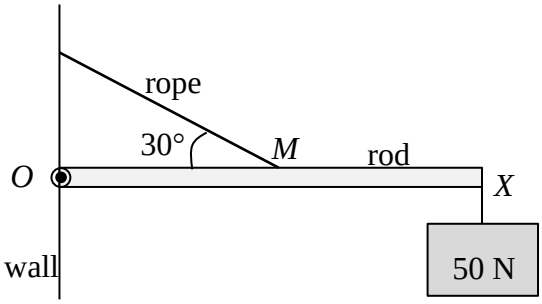
(a) The lift moves upwards with an increasing speed.

(b) The lift moves downwards with a decreasing speed.

(c) The lift moves downwards with a constant speed.

	(a)	**(b)**	**(c)**
A.	> 20 cm	< 20 cm	= 20 cm
B.	> 20 cm	> 20 cm	= 20 cm
C.	< 20 cm	= 20 cm	> 20 cm
D.	< 20 cm	< 20 cm	= 20 cm

8. A light rod *OX* is hinged smoothly to a wall at one end *O*. A weight of 50 N is attached to the other end *X* of the rod. The rod is held horizontally by a rope attached to its mid-point *M* as shown. The angle between the rod and the rope is 30°.



Find the magnitude of the reaction force acting on the rod by the wall at *O*.

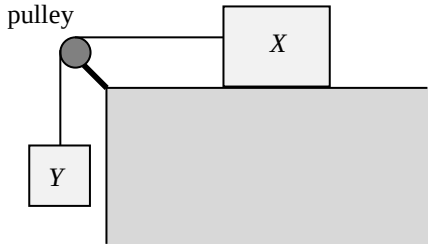
A. 0

B. 76.1 N

C. 173 N

D. 180 N

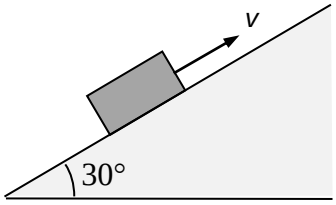
9. Two blocks *X* and *Y* are connected by a light inextensible string passing over a smooth pulley as shown. Block *X* is placed on a smooth surface. They are initially held stationary. It is known that *X* is more massive than *Y*.



When the blocks are released from rest, which of the following statements is correct?

A. The kinetic energy gained by *X* is equal to the potential energy lost by *Y*.
B. The kinetic energy gained by *X* is equal to the kinetic energy gained by *Y*.
C. The total kinetic energy gained by *X* and *Y* is equal to the potential energy lost by *Y*.
D. The net forces acting on *X* and *Y* are equal in magnitude.

10. A block of mass *m* is pushed up a rough surface inclined at 30° to the horizontal with a constant velocity *v*.



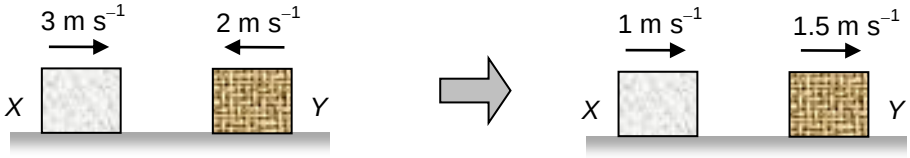
If the power of the pushing force is $2mgv$, what is the magnitude of the friction between the block and the inclined surface? Assume the air resistance is negligible.

A. $0.5mg$
B. mg
C. $1.5mg$
D. $2mg$

*11. A spacecraft is launched into space from the Earth's surface. Which of the following best describes the distance *d* of the spacecraft from the Earth's surface when the Earth's gravitational force experienced by the spacecraft is half of that on the Earth's surface? Let *R* be the radius of the Earth.

A. $d < R$
B. $d = R$
C. $R < d < 3R$
D. $d = 3R$

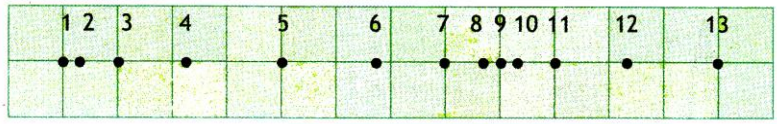
12. Two objects, X and Y, are heading each other with a speed of 3 m s^{-1} and 2 m s^{-1} respectively. After the head-on collision, they move off with a speed of 1.5 m s^{-1} and 1 m s^{-1} respectively.



Find $\dfrac{\text{mass of } X}{\text{mass of } Y}$.

A. 1 : 4
B. 4 : 1
C. 4 : 7
D. 7 : 4

13. The figure below shows the particles in a longitudinal wave travelling to the right. The particles are evenly distributed on a straight line when they are in their equilibrium positions.

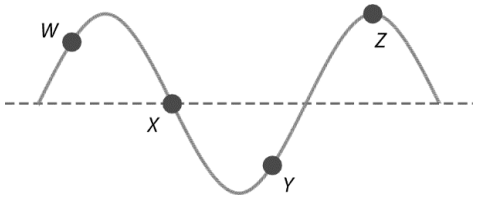


Which of the following statements is/are correct?

(1) Particles 2 and 10 are in phase.
(2) Particles 5 has the largest displacement.
(3) All particles are moving to the right at their respective speeds.

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

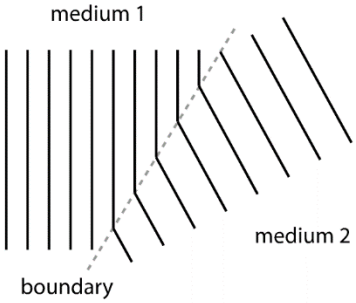
14. The diagram below shows a stationary wave formed in a light string. W, X, Y and Z are four points on the string.



At the instant shown, point W is momentarily at rest. After 3/4 period,

A. W is momentarily at rest.
B. X is either at the crest or at the trough.
C. Y is moving downwards.
D. Z is moving downwards.

15. The figure below shows the wavefronts when straight waves passes through the boundary from medium 1 to medium 2.

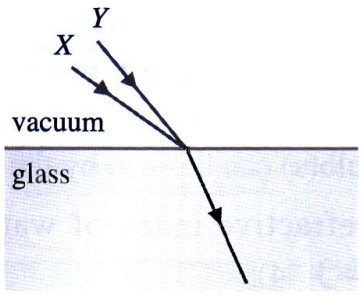


Which of the following statements is/are correct?

(1) The waves are bent towards the normal when it passes through the boundary.
(2) The waves travel slower in medium 1 than in medium 2.
(3) The frequency of the waves in medium 1 is lower than that in medium 2.

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

16. Two coloured light rays, *X* and *Y*, travel from a vacuum into glass. They undergo refraction and travel along the same path in the glass as shown.



Which of the following correctly compares the refractive indices of the glass *n* for the two rays and their speeds *v* in the glass?

	n	***v***
A.	$n_X < n_Y$	$v_X = v_Y$
B.	$n_X < n_Y$	$v_X > v_Y$
C.	$n_X > n_Y$	$v_X = v_Y$
D.	$n_X > n_Y$	$v_X < v_Y$

17. Consider a light ray travels from a diamond to water. What is the critical angle for the diamond-water interface?

Given: refractive index of diamond = 2.42
refractive index of water = 1.33

A. 24.4°
B. 33.3°
C. 44.2°
D. 48.8°

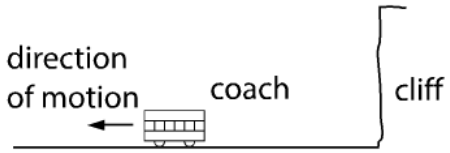
*18. An object is placed in front of a diverging lens of focal length 24 cm. An image is formed 8 cm from the lens. Find the object distance and the magnification of the image.

	object distance	**magnification of image**
A.	6 cm	0.75
B.	6 cm	1.33
C.	12 cm	0.67
D.	12 cm	1.5

*19. A fine diffraction grating gives the 3rd order bright fringe at 45.0° measured from the central brightness. What is the angular position of the 2nd order bright fringe?

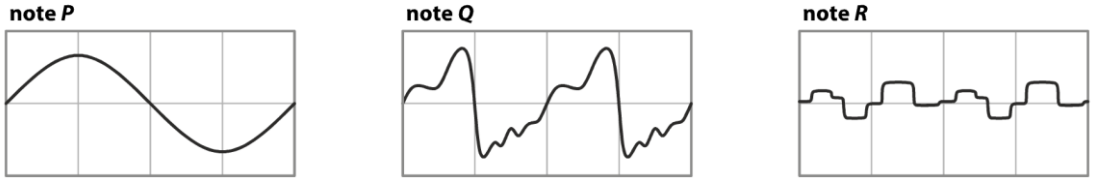
A. 22.5°
B. 28.1°
C. 30.0°
D. Cannot be determined because of insufficient data.

20. A coach, initially at rest, accelerates uniformly at 2 m s^{-2} away from a cliff. At the instant the coach starts off, the driver honks the coach horn. He hears the echo 6 s later. What is the initial distance of the coach from the cliff? Take the coach as a point object and given that the speed of sound in the air is 340 m s^{-1}.



A. 500 m
B. 1000 m
C. 1500 m
D. 2000 m

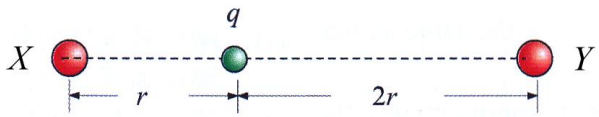
21. The diagram below shows the CRO traces produced by three different notes. The settings of the CRO are the same.



Which pair of the above notes has the same pitch?

A. Notes *Q* and *R*
B. Notes *P* and *Q*
C. Notes *P* and *R*
D. They all have different pitches.

22. Two identical point charges, *X* and *Y*, are separated by a distance of 3*r*. A point charge *q* is placed at a distance *r* from *X* as shown.



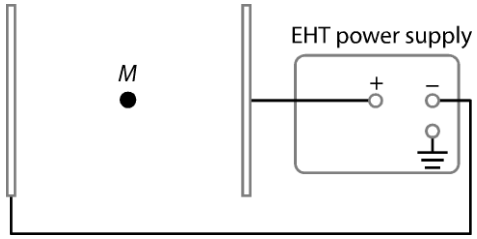
If the magnitude of the electric force exerted on *q* by *X* is *F*, what is the magnitude of the resultant electric force acting on *q*?

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

23. A length of uniform metal wire of resistance *R* is cut in three equal parts. The three lengths are wrapped together side by side to make a thicker wire. What is the resistance of this new wire?

A. $9R$
B. $3R$
C. $\frac{R}{3}$
D. $\frac{R}{9}$

*24. A uniform electric field is set up between two charged parallel plates connected to an EHT power supply as shown. Initially, *M* is the mid-point between the plates.



In which case(s) would the electric field at *M* be unchanged?

(1) Decrease the space between the two plates.

(2) Move both plates together to the left hand side by the same distance such that *M* becomes closer to the positive plate.

(3) Earth the negative terminal.

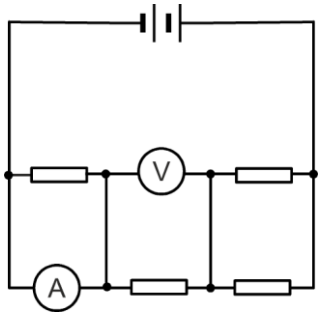
A. (1) only

B. (2) only

C. (1) and (3) only

D. (2) and (3) only

25. In the circuit shown, the four resistors are identical. Both the ammeter and the voltmeter are ideal and the internal resistance of the battery is zero. If the voltage of the battery is 6 V, what is the reading of the voltmeter?



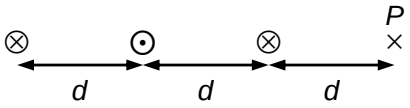
A. 6 V

B. 4 V

C. 3 V

D. 2 V

26. Three long straight parallel wires are arranged side by side as shown below. If each of them carries a current I in the direction as shown, what is the magnetic field at P?



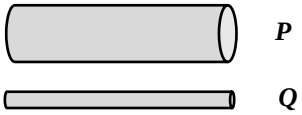
A. $\frac{5\mu_0 I}{12\pi d}$ (pointing upwards)

B. $\frac{5\mu_0 I}{12\pi d}$ (pointing downwards)

C. $\frac{11\mu_0 I}{12\pi d}$ (pointing upwards)

D. $\frac{11\mu_0 I}{12\pi d}$ (pointing downwards)

27. Two straight wires P and Q, made of same material and connected to the same constant d.c. voltage supply, are placed parallel to each other. Their lengths are the same but P is thicker than Q. It is found that the wires attract each other.



Which of the following statements is/are correct?

(1) The directions of current flow in both wires are the same.

(2) The magnetic force acting on P is larger than that on Q.

(3) If the d.c. voltage is doubled, the magnetic force acting on P is also doubled.

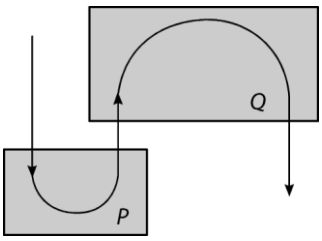
A. (1) only

B. (3) only

C. (1) and (2) only

D. (2) and (3) only

*28. A charged particle moves horizontally into two vertical magnetic fields P and Q as shown. Which of the following descriptions about the fields is correct?



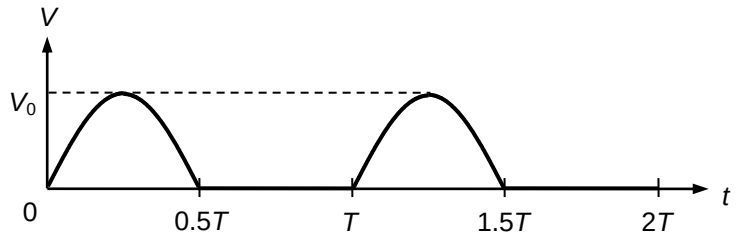
A. They are in the same direction. The field in P is stronger.

B. They are in the same direction. The field in Q is stronger.

C. They are in opposite directions. The field in P is stronger.

D. They are in opposite directions. The field in Q is stronger.

* 29. A resistor of resistance R is connected to a power supply. The potential difference V across the resistor varies periodically with time t as shown. In the graph, T is the period. What is the average power dissipated by the resistor?



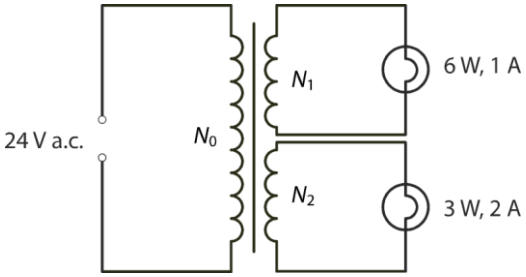
A. $\frac{V_0^2}{4R}$

B. $\frac{V_0^2}{2R}$

C. $\frac{V_0^2}{\sqrt{2}R}$

D. $\frac{V_0^2}{R}$

* 30. The figure below shows an ideal transformer with two secondary coils, each connected to a light bulb working at its rated power. The two bulbs are marked '6 W, 1 A' and '3 W, 2 A' respectively.



What are the turns ratios $N_0 : N_1 : N_2$ of the transformer?

A. 8 : 2 : 1

B. 8 : 1 : 2

C. 16 : 2 : 1

D. 16 : 4 : 1

31. The age of a living man cannot be determined by carbon-14 dating because

A. the activity of carbon-14 in a living body is too low to be detected.

B. this dating method is harmful to lives.

C. the ratio of radioactive to non-radioactive carbon does not change in a living man.

D. there is no carbon-14 inside a living man.

32. Which of the following statements about the fission and fusion reactions is/are correct?

(1) Both result in loss in mass.

(2) Both involve chain reaction.

(3) Both are currently used by power stations in generation of electricity.

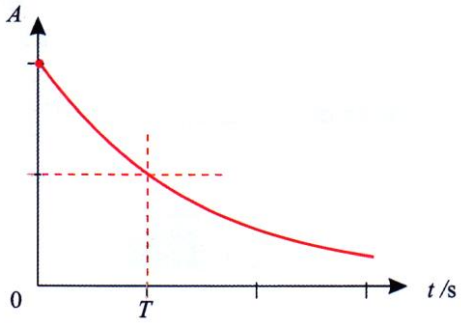
A. (1) only

B. (3) only

C. (1) and (2) only

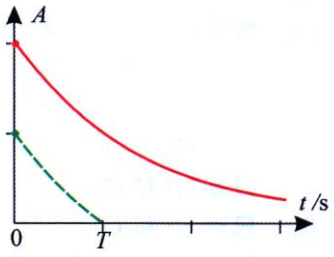
D. (2) and (3) only

33. The graph shows how the activity A of a radioactive sample varies with time t.

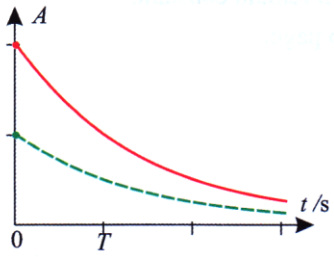


Which of the following shows the A-t graph (in dotted line) for another sample of the same radioisotope but starting with half the initial activity?

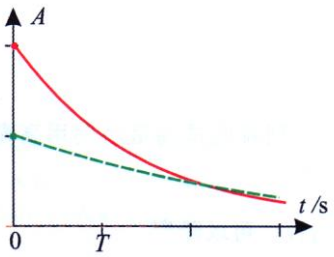
A.



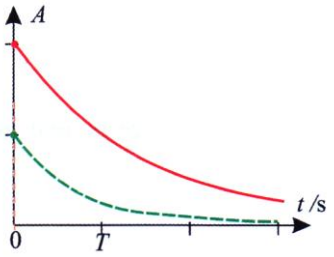
B.



C.



D.



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

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma A T^4$	Stefan's law
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	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
$P = \frac{1}{2}\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	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 width 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.	$N = N_0e^{-kt}$	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

Solution to S6 Physics Mock Paper 1A (2021 – 2022)

1 – 5:	ADBDD
6 – 10:	ABDCC
11 – 15:	ADACA
16 – 20:	DBCBB
21 – 25:	ACDDB
26 – 30:	BACAD
31 – 33:	CAB