PHY

PAPER 1A

QUEEN'S COLLEGE
PHYSICS MOCK EXAMINATION 2020
6 Feb 2020

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 the knowledge of extension components.

1. Which of the following statements about heat is/are correct?

(1) It is the energy transferred from one body to another as a result of a temperature difference.
(2) when we rub our hands, heat is produced.
(3) W is a unit of heat.

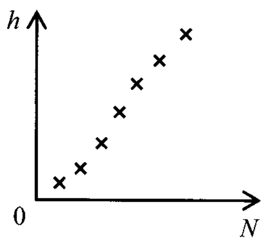
A. (l) only B. (2) and (3) only C. (l) and (2) only
D. (1), (2) and (3)

2. Four cups of liquids, which are initially at 25 ^{o}C, are heated at the same rate. The masses of the liquids are the same. If the liquids start to boil at the same time, which of them has the highest specific heat capacity? (Assume heat loss to the surroundings is negligible.)

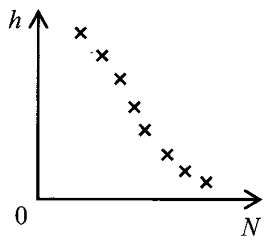
	liquid	**boiling point**
A.	*M*	65 ^{o}C
B.	*N*	80 ^{o}C
C.	*O*	l30 ^{o}C
D.	*P*	190 ^{o}C

***3**. In a 3-D kinetic model of gas, the supply voltage is fixed. Identical masses are added onto the piston one by one and the height of the piston is recorded. Which of the following may correctly show the relation between the number of masses added *N* and the height of the piston *h*?

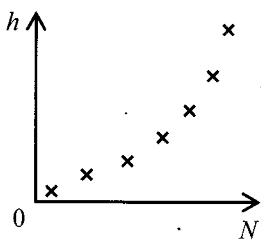
A.



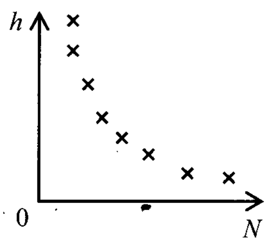
B.



C.



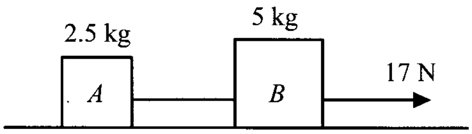
D.



4. A ball X is thrown vertically downwards with a speed of 25.0 ms^{-1} from the top of a tower of height 90 m. Meanwhile, another ball Y is thrown vertically upwards from the ground at 25.0 ms^{-1}. Assume air resistance is negligible. How many seconds later will the balls meet each other?

A. 1.80 s
B. 2.47 s
C. 3.03 s
D. 4.29 s

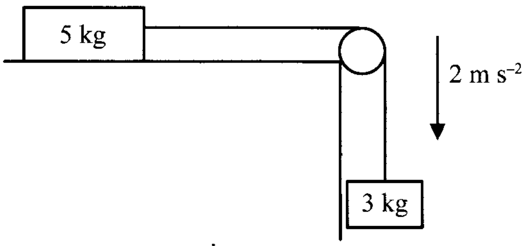
5. Two blocks are connected by an inextensible string as shown in the figure.



The objects are moved together by an external force of 17 N. The frictional forces acting on the blocks A and B are 2 N and 3 N respectively. Find the tension in the string.

A. 4.0 N
B. 5.7 N
C. 6.0 N
D. 7.0 N

6. A 5 kg mass and a 3 kg mass are connected by an inextensible string via a pulley as shown. When the 3 kg mass is released, it falls with an acceleration of 2 ms^{-2}.



Assume the pulley has negligible mass and the friction between the string and the pulley is negligible. If the 3 kg mass falls by 1 m, find the work done against the friction between the 5 kg mass and the surface.

A. 10 J
B. 13.4 J
C. 16 J
D. 23.4 J

7. An object is acted on by a net force F for time t. Which of the following statements must be correct?

(1) The final momentum of the object has the same direction as F.
(2) The momentum of the object is not conserved.
(3) The final momentum of the object is Ft

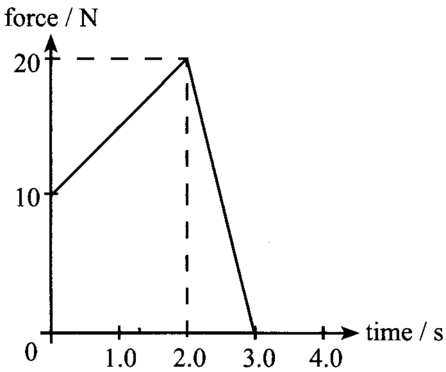
A. (2) only
B. (1) and (2) only
C. (1) and (3) only
D. (1), (2) and (3)

***8.** An object is projected at an angle from the horizontal ground. If the air resistance is negligible, which of the following descriptions about the object at its highest position must be correct?

(1) The net force acting on the object reaches its maximum value.
(2) The speed of the object reaches its minimum value.
(3) The time taken for the object to reach its highest position is equal to one-half of the total time of travel.

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

9. The graph shows the time variation of the net force acting on an object of mass 5 kg. The object is initially at rest and its subsequent motion is along a straight line. The final speed of the object is



A. 6 ms^{-2}.
B. 8 ms^{-2}
C. l2 ms^{-2}
D. 35 ms^{-2}

***10.** A planet of mass *M* and radius *R* rotates so rapidly that a man at the equator just feels weightless. If *G* denotes the universal gravitational constant, what is the period of rotation of the planet?

A. $2\pi\sqrt{\frac{R^3}{GM}}$

B. $2\pi\sqrt{\frac{R^2}{GM}}$

C. $2\pi\sqrt{\frac{R}{GM}}$

D. $2\pi\sqrt{\frac{GM}{R^3}}$

11. A ball loses 10% of its kinetic energy when it rebounds from a concrete floor. The ball is thrown vertically downward from a height of 18 m. With what speed must it be thrown so that it will bounce back to the same height? (Assume the air resistance is negligible.)

A. 6.01 ms^{-1}
B. 6.26 ms^{-1}
C. 8.45 ms^{-1}
D. 8.90 ms^{-1}

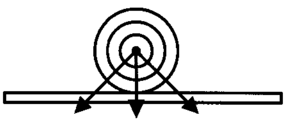
12. A ball of mass 0.2 kg moving towards right hand side hits a vertical wall with a horizontal speed of 30 ms^{-1}. It rebounds with a speed of 25 ms^{-1} in the opposite direction. If the time of impact is 0.2 s, what is the average force acting on the wall by the ball?

A. 5 N to the left
B. 5 N to the right
C. 55 N to the left
D. 55 N to the right

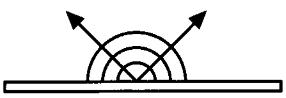
13. Which of the following pairs of forces is an action-and-reaction pair as described in Newton's third law of motion?

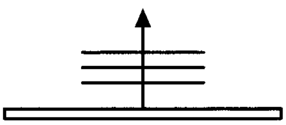
A. the weight of a box on a table and the normal reaction acting on it by the table.
B. the force pushing a box which is moving with uniform velocity along a horizontal surface and the friction acting on the box.
C. the attractive forces acting on each other of two nearby gas molecules.
D. the lifting force on an aircraft flying with uniformly velocity and the weight of the. aircraft

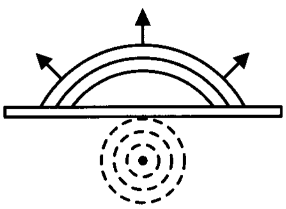
14. A point dipper produces a series of circular water waves in a ripple tank. The waves approach a straight barrier as shown.

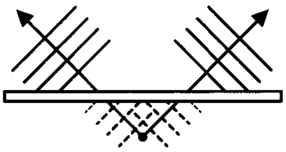


Which of the following best shows the reflected waves from the barrier?

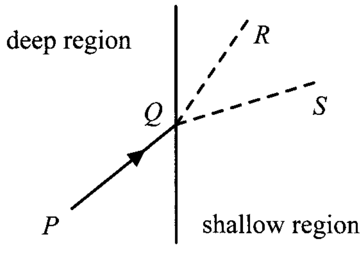
A.


B.


C.


D.


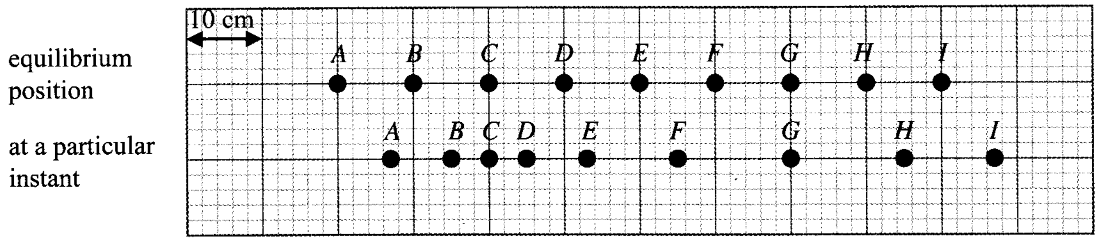
15. As shown in the figure, a series of water waves are travelling across deep region at 0.8 ms^{-1} along the direction *PQ*. The waves travel across a boundary into shallow region.



Which of the following best describes the direction and the wave speed of the water waves in the shallow region?

	direction	wave speed
A.	*QR*	0.6 ms^{-1}
B.	*QR*	1.2 ms^{-1}
C.	*QS*	0.6 ms^{-1}
D.	*QS*	1.2 ms^{-1}

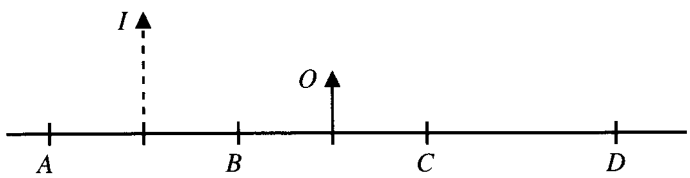
16. A longitudinal wave is travelling from left to right along a spring. The following shows the positions of some particles on the spring at a particular instant.



If the longitudinal wave propagates at 1 ms^{-1}, where is the compression and rarefaction 0.5 s later?

	compression	rarefaction
A.	*F*	*B*
B.	*E*	*I*
C.	*A*	*E*
D.	*H*	*D*

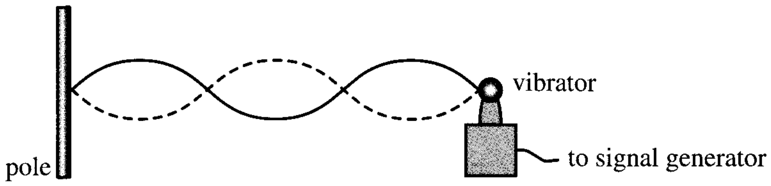
17. The figure shows an object *O* and the corresponding image *I* formed by a lens.



Which of the following may correctly describe the nature and the position of the lens used?

	nature	position
A.	convex	left of *A*
B.	concave	*B*
C.	concave	between *C* and *D*
D.	convex	between *C* and *D*

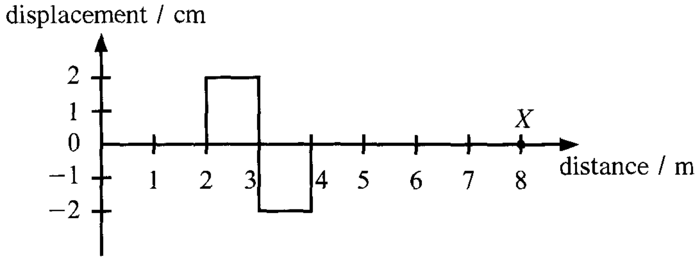
18. One end of an elastic string is attached to a pole while the other end is attached to a vibrator which is connected to a signal generator. The frequency of the vibrator is slowly increased from zero. When the vibrating frequency reaches 120 Hz, the following stationary wave pattern is observed.



At which of the following frequencies can another stationary wave pattern be observed?

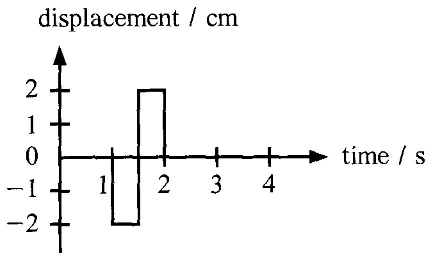
A. 60 Hz
B. 70 Hz
C. 80 Hz
D. 90 Hz

19. The figure shows the displacement-distance graph of a pulse at time $t = 0$. The pulse is travelling to the right at a speed of 4 ms^{-1}.

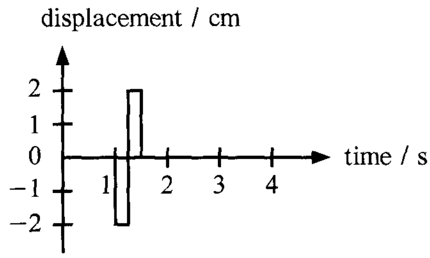


Which of the following graphs best represents how the displacement of the particle *X* varies from $t = 0$ to $t = 4$ s?

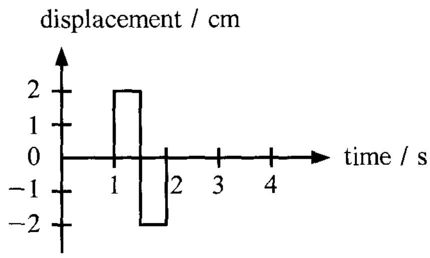
A.



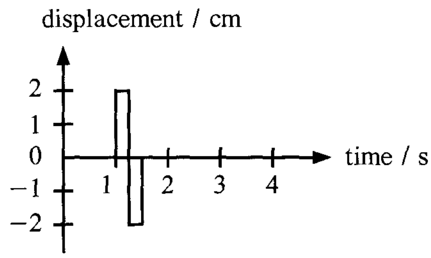
B.



C.



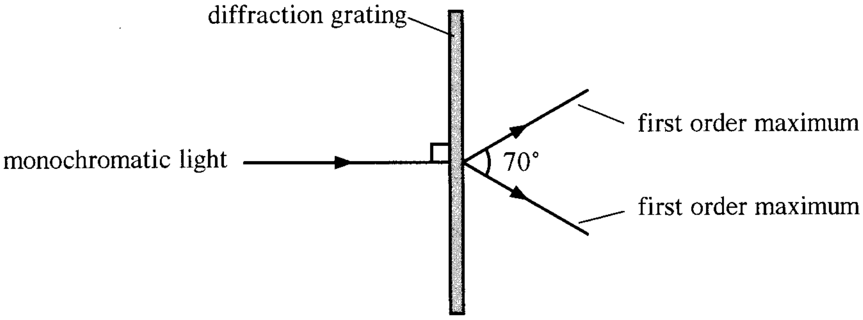
D.



20. Which of the following statements about standing waves is NOT correct?

A. The particles at antinodes have zero displacement.
B. Particles between adjacent nodes vibrate with different amplitudes.
C. Particles between adjacent nodes are vibrating in phase with each other.
D. Particles immediately on either side of a node are moving in opposite directions.

***21.** As shown in the figure below, a beam of monochromatic light is directed normally onto a diffraction grating of slit spacing 1 x 10^{-6} m. The angle between the first order maxima is measured to be 70^{o}.



What is the wavelength of the light?

A. 287 nm
B. 470 nm
C. 574 nm
D. 940 nm

22. Interference pattern produced by a two coherent sources are observed at a distance of 1 m from the sources. In which one of the following cases are the maxima closest to each other?

A. Surface water waves of wavelength 10 mm from sources of 200 mm apart
B. Sound waves of wavelength 20 mm from sources of 50 mm apart
C. Blue light of wavelength 450 nm from sources of 2 mm apart
D. Red light of wavelength 700 nm from sources of 4 mm apart

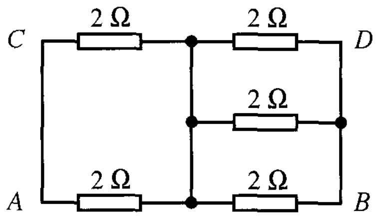
23. Three identical balls are suspended separately from insulating threads. Ball *X* has a net charge of 1.0 x 10^{-8} C while balls *Y* and *Z* are neutral. Balls *X* and *Y* are brought into contact and then separated. Then ball *Y* is brought momentarily into contact with ball *Z* and then separated. When balls *X* and *Z* are placed 1.0 m apart, the electric force between them is

A. 1.0 x 10^{-7} N.
B. 1.1 x 10^{-7} N.
C. 2.2 x 10^{-7} N.
D. 9.0 x 10^{-7} N.

24. An artificial pacemaker is a device used to regulate the beating of the heart by emitting electrical pulses. A typical artificial pacemaker can produce pulses of 16 mA current. If the duration of each pulse is 0.5 ms and the pacemaker generates 100 pulses each minute, find the total charge delivered by the pacemaker each minute.

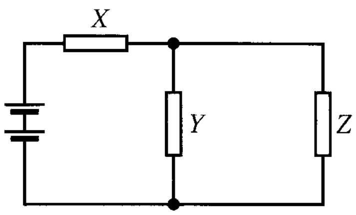
A. 8 x 10^{-6} C
B. 8 x 10^{-4} C
C. 0.016 C
D. 160 C

25. In the circuit shown above, the resistance of each resistor is 2 Ω. What are the equivalent resistances across *A*B and *AD* respectively?



	AB	***AD***
A.	1.67 Ω	1.67 Ω
B.	1.67 Ω	3.67 Ω
C.	2.5 Ω	1 Ω
D.	2.5 Ω	1.67 Ω

26. Three resistors *X*, *Y* and *Z*, of equal resistance, are connected to a battery of negligible internal resistance as shown below.



If the power output of the battery is 18 W, what is the power dissipated by heating in resistor *Z*?

A. 3W
B. 4.5W
C. 6W
D. 9W

27. A long wire is wound into a long solenoid with radius *R* and *N* turns. When a current *I* flows through the wire, a magnetic field *B* is set up inside the solenoid. If the wire is wound into a long solenoid with radius 2*R* such that the length is the same as before, what is the magnetic field inside the solenoid?

A. 0.25*B*
B. 0.5*B*
C. *B*
D. 2*B*

***28.** A coil with cross-sectional area *A* and *N* turns is placed in a uniform magnetic field *B*. Figure (a) shows the initial position of the coil. If the coil rotates about its axis by 180° as shown in Figure (b), what is the magnitude of the change in the flux linkage of the coil?

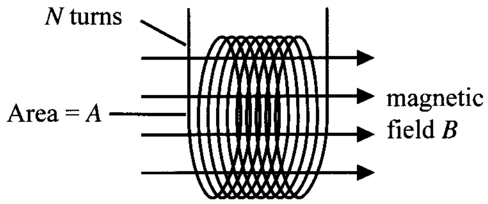


Figure (a)

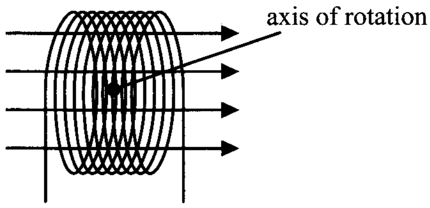
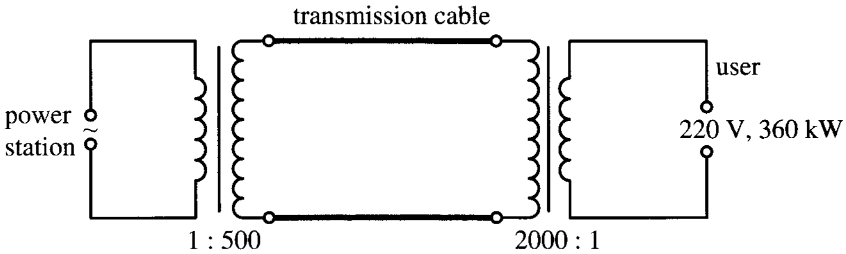


Figure (b)

A. zero
B. $2AB$
C. NAB
D. $2NAB$

***29.** In the high-voltage transmission network shown in below diagram, the efficiency of each transformer is 90%. If the overall efficiency of the network is 80%, find the power loss in the transmission cable.



A. 3.6 kW
B. 4.5 kW
C. 5.0 kW
D. 5.4 kW

***30.** Electrical energy is usually transmitted at high voltage from the power station to users. Which of the following statements about the transmission is/are correct?

(1) The power lost in the cables can be reduced if the electricity is transmitted at high voltage.
(2) The current in the transmission cables is very large.
(3) No step-down transformers are needed in the transmission grid.

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

31. The half-life of a radioisotope is 12 minutes. A sample of this isotope is put in front of a GM-counter and the corrected count rate is measured to be 3200 counts per minute at 4:00 p.m. At what time on that day will the corrected count rate drop to 100 counts per minute?

A. 4:48 p.m.
B. 5:00 p.m.
C. 5:12 p.m.
D. 6:00 p.m.

32. When people are exposed to radiation, which of the following will determine the damage to their health?

(1) the intensity of radiation
(2) the time of exposure
(3) the type of radiation

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

33. Which of the following about the nucleus of an atom can be deduced by analyzing the path of α particles which have been scattered in passing through thin metal foils?

(1) It carries same type of charge as an α particle.
(2) It concentrates at the centre of the atom.
(3) It composes of protons and neutrons.

A. (1) only
B. (1) and (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	$e = 1.60 \times 10^{-19}\ \text{C}$	
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
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda_0}\right\rvert$	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
$P = \frac{1}{2}\rho A v^3$	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.	$N = N_0 e^{-kt}$	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