Diploma Programme
Programme du diplôme
Programa del Diploma

# Physics
# Higher level
# Paper 1

25 April 2024

**Zone A** afternoon | **Zone B** afternoon | **Zone C** afternoon

1 hour

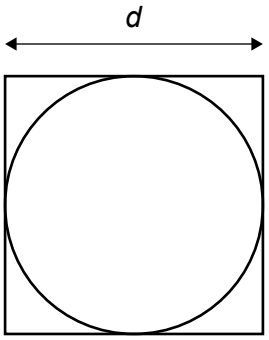
## Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[40 marks]**.

2224 – 6701

18 pages

**1.** The diameter of a particular circle is equal to the length of the side of a square. The length of one side of the square is $d \pm \Delta d$.




The area of the circle is $\pi \times \frac{d^2}{4}$.

What is the $\frac{\text{fractional uncertainty in the area of the square}}{\text{fractional uncertainty in the area of the circle}}$?

A. $\frac{4}{\pi}$

B. 1

C. $\frac{\pi}{4}$

D. $\frac{1}{2}$

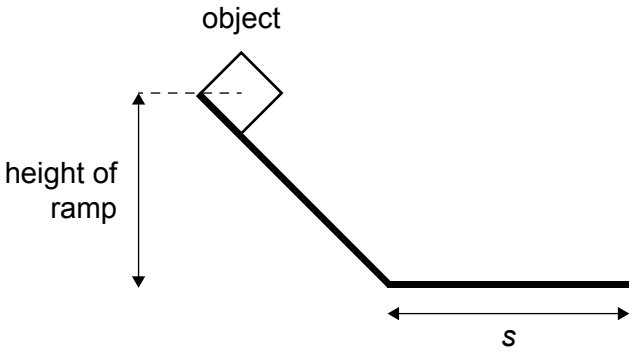
**2.** An object is launched upwards at an initial velocity $+u$ at an angle of $\theta$ to the horizontal. Air resistance is negligible.

At a later time the object has a vertical displacement of zero.

What are the horizontal component of the velocity and the vertical component of the velocity at this later time?

| | **Horizontal component of the velocity** | **Vertical component of the velocity** |
|---|---|---|
| A. | $u\cos\theta$ | $u\sin\theta$ |
| B. | $u\cos\theta$ | $-u\sin\theta$ |
| C. | $u\sin\theta$ | $u\cos\theta$ |
| D. | $u\sin\theta$ | $-u\cos\theta$ |

**3.** An object is released from rest and slides down a frictionless ramp. The object then leaves the ramp and slides along a rough horizontal surface. The object stops in a distance *s* along the ramp.




The coefficient of dynamic friction between the object and the rough horizontal surface is $\mu$.

What is the height of the ramp?

A. $\mu g s$

B. $\frac{s}{2g\mu}$

C. $\frac{s}{\mu}$

D. $\mu s$

**4.** An object with mass *m* falls through the air with a terminal speed *v* for a short time *t*.

What is the work done on the air by the falling object during this time?

A. $mgvt$

B. $mgt$

C. $\frac{mgv}{t}$

D. $\frac{mv}{t}$

**5.** An electric motor has an energy of 1.8 kJ transferred to it in 0.50 minutes. The efficiency of the motor is 40 %.

What is the useful power output of the motor?

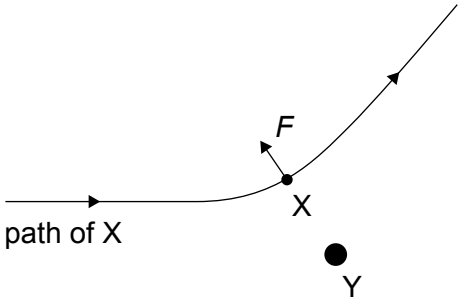
A. 1.5 W

B. 24 W

C. 150 W

D. 360 W

**6.** A particle X has a small positive charge and is free to move. Y has a large positive charge and is fixed. X is initially moving towards Y.




Y exerts an electric force *F* on X. Gravitational forces are negligible.

The magnitude of the force exerted by X on Y is

A. zero.

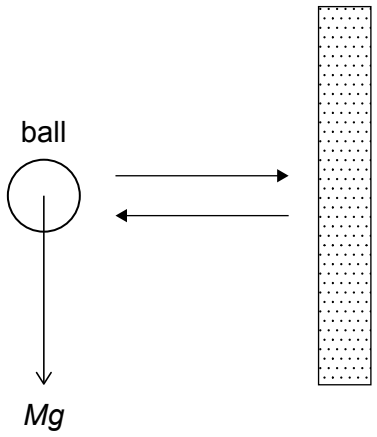
B. less than the magnitude of *F*.

C. equal to the magnitude of *F*.

D. greater than the magnitude of *F*.

**7.** A ball, moving horizontally, strikes a vertical wall. The ball rebounds horizontally.

The mass of the ball is $M$ and the change in magnitude of the momentum of the ball is $\Delta p$.




What is the magnitude of the impulse acting on the wall due to the ball?

A. $Mg + \Delta p$

B. $Mg - \Delta p$

C. $2\Delta p$

D. $\Delta p$

**8.** An assumption of the kinetic model of an ideal gas is that each gas particle

A. has the same speed as all the others.

B. collides elastically with the container walls.

C. travels parallel to the container walls.

D. has a momentum that does not change.

**9.** Two containers X and Y are filled with the same ideal gas and connected by a tube of negligible volume. The volume of X is twice the volume of Y.

X is held at a temperature of 150 K and Y is held at a temperature of 300 K.

What is $\frac{\text{mass of gas in X}}{\text{mass of gas in Y}}$ ?

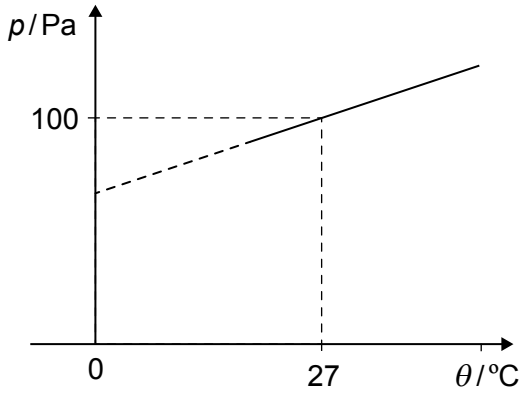
A. $\frac{1}{4}$

B. 1

C. 2

D. 4

**10.** The graph shows the variation of pressure $p$ with Celsius temperature $\theta$ for $n$ moles of an ideal gas. The volume $V$ of the gas is constant.




What is $\frac{nR}{V}$ for the gas?

A. 0.27

B. 0.33

C. 3.0

D. 3.7

**11.** An object is undergoing simple harmonic motion.

For this object, what is the phase difference between the variation of displacement with time and the variation of acceleration with time?

A. 0

B. $\frac{\pi}{4}$ rad

C. $\frac{\pi}{2}$ rad

D. $\pi$ rad

**12.** A vibrating string is fixed at both ends. The frequency of the second harmonic of a stationary wave generated on the string is 240 Hz.

What is the frequency of the fifth harmonic?

A. 96 Hz

B. 360 Hz

C. 600 Hz

D. 1200 Hz

**13.** A longitudinal wave travels along a horizontal spring. The frequency of the wave is 4.0 Hz and the speed of the wave is $2.0\,m\,s^{-1}$.

A particle in the wave

A. changes direction 4 times every second.

B. moves in phase with a particle 0.25 m away.

C. oscillates with a time period of 0.25 s.

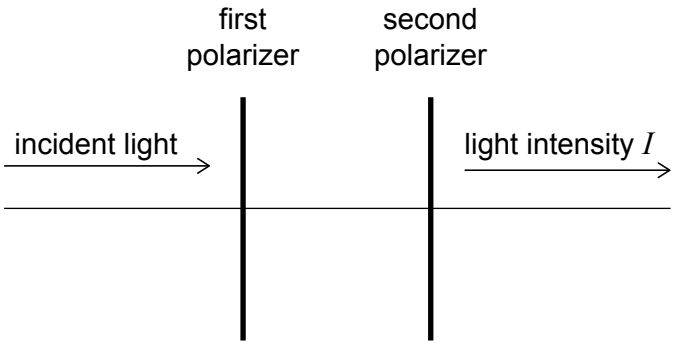
D. travels at a constant speed of $2.0\,m\,s^{-1}$.

**14.** Unpolarized light is incident on a pair of polarizers.

The polarizing axis of the second polarizer is at 60° to the axis of the first polarizer.

The light emerging from the second polarizer has an intensity $I$.

$\cos(60°) = 0.50$




What light intensity is incident on the first polarizer?

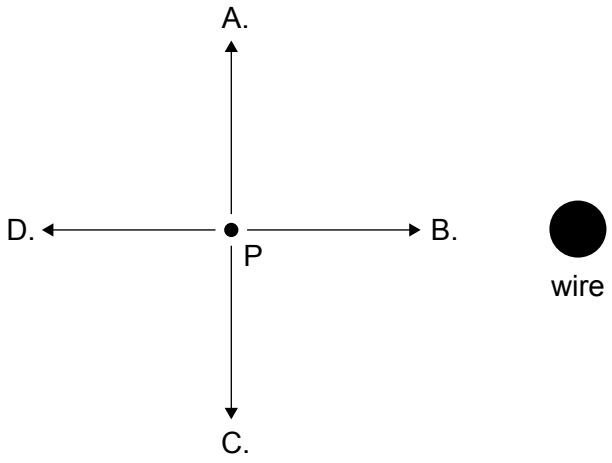
A. $8I$

B. $4I$

C. $2I$

D. $\frac{I\sqrt{2}}{2}$

**15.** Electrons are moving in a long wire that is normal to the plane of the paper. The electrons move into the paper.




What is the direction of the magnetic field at point P?

**16.** What is a possible unit of electrical resistance?

A. $WA^{-2}$

B. $AV^{-1}$

C. $VW^{-2}$

D. $WV^{-2}$

**17.** A particle with charge $Q$ is accelerated from rest through a potential difference $V$ over a distance $s$.

The particle then enters a magnetic field of strength $P$ at right angles to the magnetic field direction.

What single change will make the radius of curvature of the path of the particle smaller?

A. Increase $P$

B. Decrease $s$

C. Increase $V$

D. Decrease $Q$

**18.** An object of mass $m$ is attached to the end of a rope. The object is rotated in a horizontal circle at the end of the rope with an increasing speed. The rope breaks when the angular velocity $\omega$ is reached.

At what other combination of mass and angular velocity will this rope break?

| | Mass | Angular velocity |
|---|---|---|
| A. | $3m$ | $\frac{\omega}{2}$ |
| B. | $4m$ | $\frac{\omega}{4}$ |
| C. | $3m$ | $\frac{\omega}{4}$ |
| D. | $4m$ | $\frac{\omega}{2}$ |

**19.** What are three fundamental forces listed in decreasing order of strength?

A. Strong nuclear, gravity, electromagnetic

B. Electromagnetic, strong nuclear, gravity

C. Strong nuclear, electromagnetic, gravity

D. Gravity, weak nuclear, electromagnetic

**20.** Which equation is an example of $\beta^+$ decay?

A. $^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + \mathrm{e}^- + \nu_\mathrm{e}$

B. $^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + \mathrm{e}^+ + \bar{\nu}_\mathrm{e}$

C. $^{23}_{12}\mathrm{Mg} \rightarrow {}^{23}_{11}\mathrm{Na} + \mathrm{e}^+ + \bar{\nu}_\mathrm{e}$

D. $^{23}_{12}\mathrm{Mg} \rightarrow {}^{23}_{11}\mathrm{Na} + \mathrm{e}^+ + \nu_\mathrm{e}$

**21.** The rest mass of an O-17 nucleus is $m_\mathrm{O}$.

What is the binding energy of a $^{17}_{8}\mathrm{O}$ nucleus?

A. $(8m_\mathrm{p} + 9m_\mathrm{n} - m_\mathrm{O}) \times c^2$

B. $(8m_\mathrm{p} + 9m_\mathrm{n} + m_\mathrm{O}) \times c^2$

C. $(9m_\mathrm{p} + 8m_\mathrm{n} + m_\mathrm{O}) \times c^2$

D. $(9m_\mathrm{p} + 8m_\mathrm{n} - m_\mathrm{O}) \times c^2$

**22.** Three changes that may affect the climate are:

I. Increasing the capture of carbon dioxide and then storing it

II. Changing the fuel of power stations from natural gas to Uranium-235

III. Changing the fuel of power stations from natural gas to oil

Which changes are likely to **reduce** the enhanced greenhouse effect?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**23.** The power emitted by a spherical black body at absolute temperature $T$ is $P$.

The absolute temperature of the black body is halved and its radius is doubled so that the power emitted becomes $P'$.

What is $\frac{P'}{P}$?

A. $\frac{1}{16}$

B. $\frac{1}{8}$

C. $\frac{1}{4}$

D. $\frac{1}{2}$

**24.** Control rods are lowered into a thermal nuclear fission reactor to

A. decrease the overall rate of fission occurring in the reactor.

B. increase the overall rate of fission occurring in the reactor.

C. reduce the energies of fission neutrons to thermal values.

D. increase the energies of fission neutrons to thermal values.

**25.** The equation $P = \frac{1}{2} A\rho v^3$ gives the maximum power output $P$ of a wind turbine when the wind speed is $v$.

This is a maximum power output because

A. the wind leaves the wind turbine with non-zero speed.

B. a nearby wind turbine causes a shadow effect.

C. the air is compressed by the wind turbine blades.

D. the wind turbine blades require a constant wind supply.

**26.** An object performs simple harmonic motion. When the displacement of the object is $\frac{x_0}{2}$ the kinetic energy of the object is *E.*

What is the total energy of the motion?

A. $\frac{3E}{4}$

B. $\frac{4E}{3}$

C. $2E$

D. $4E$

**27.** Light of wavelength 400 nm is incident normally on a diffraction grating. The slit separation of the diffraction grating is 1.0 μm.

What is the greatest number of maxima that can be observed ?

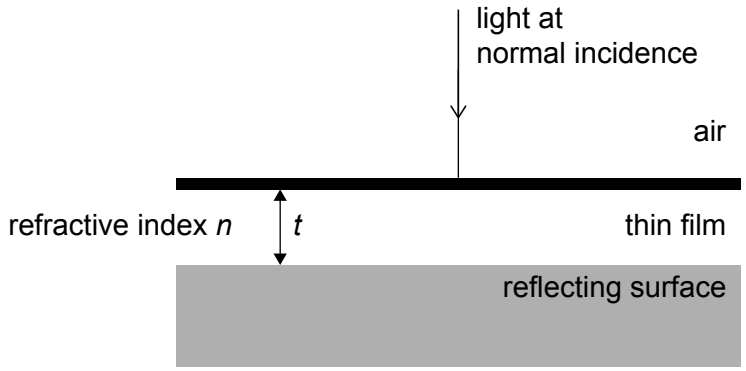
A. 2

B. 3

C. 5

D. 7

**28.** A reflecting surface is covered with a thin film of refractive *n* and thickness *t*. The refractive index of the reflecting surface is greater than the refractive index of the thin film.




Light of wavelength $\lambda$ is incident normally from air on the thin film.

What is the minimum thickness of the film for which no light is reflected back into the air?

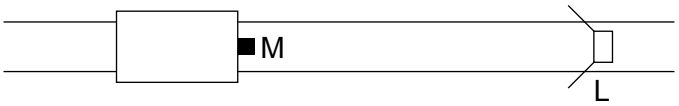
A. $\frac{\lambda}{4n}$

B. $\frac{\lambda}{4}$

C. $\frac{\lambda}{2n}$

D. $\frac{\lambda}{2}$

**29.** A microphone M on a moving train detects the sound from a stationary loudspeaker L placed on the track. The track is straight.




L emits a sound of constant frequency. The frequency detected by M is continuously decreasing.

The train is moving

A. away from L at an increasing speed.

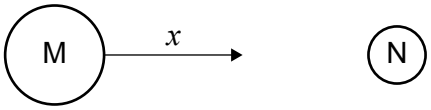
B. away from L at a constant speed.

C. towards L at a constant speed.

D. towards L at an increasing speed.

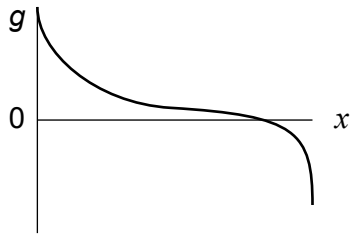
**30.** Two spheres M and N are far from any other mass. The mass of sphere M is greater than the mass of sphere N.

A distance $x$ is measured from the surface of M along the line between the centres of M and N. The variation with $x$ of the gravitational field strength *g* is determined.

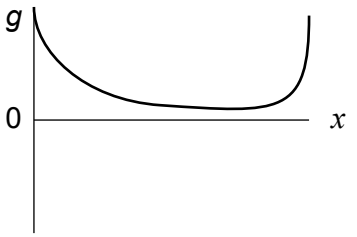



What is the variation of *g* with $x$?

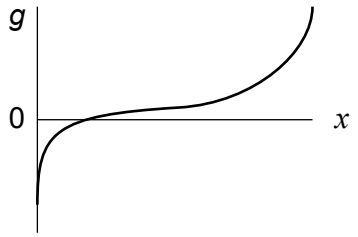
A.



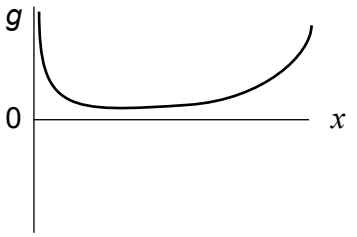

B.




C.




D.




**31.** The radius of a spherical planet is *R*. At the surface of the planet the gravitational potential is $-V$.

What is the gravitational potential *R* above the surface?

A. $-2V$

B. $-V$

C. $-\frac{V}{2}$

D. $-\frac{V}{4}$

**32.** Four positive charges are fixed at the corners of a square that has a diagonal length of $d$. Three of the charges have a charge of $+Q$.

The total electric potential at the centre of the square is $\frac{10kQ}{d}$ .

What is the magnitude of the fourth charge?

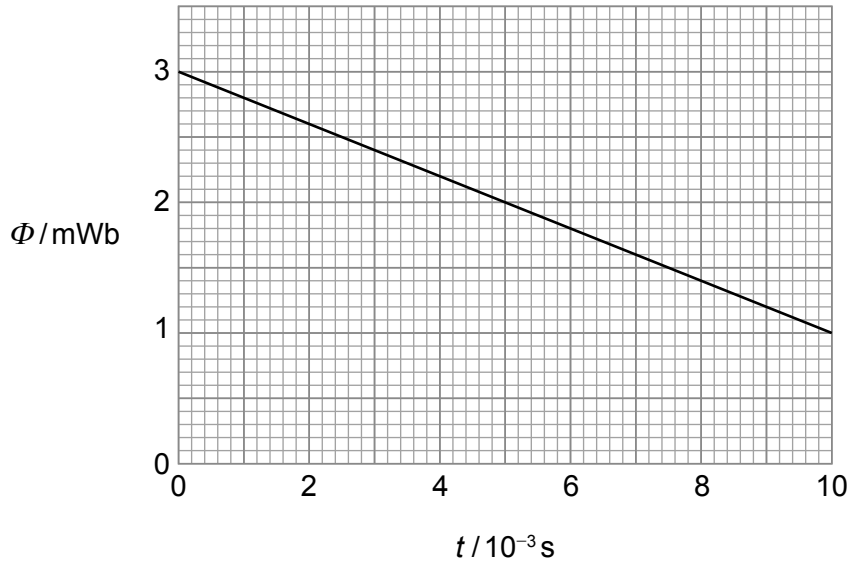
A. $Q$

B. $Q\sqrt{2}$

C. $2Q$

D. $4Q$

**33.** The magnetic flux $\Phi$ varies with time $t$ in a coil as shown. The coil has 250 turns.




What is the magnitude of the emf in the coil as a result of this flux change?

A. 0.20 V

B. 0.30 V

C. 50 V

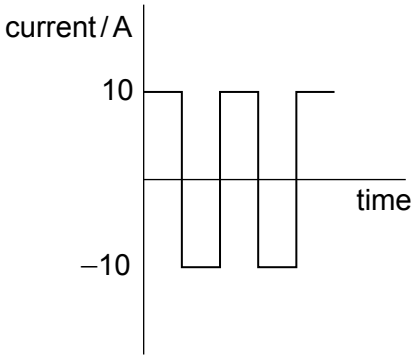
D. 75 V

**34.** Electrical energy is to be transferred from a power station to users using an ac power distribution system.

What are the conditions for the transmission voltage and the transmission current for the most efficient energy transfer?

| | **Transmission voltage** | **Transmission current** |
|---|---|---|
| A. | High | High |
| B. | High | Low |
| C. | Low | High |
| D. | Low | Low |

**35.** The variation with time of the current in a resistor is shown.




What is the root mean square (rms) current?

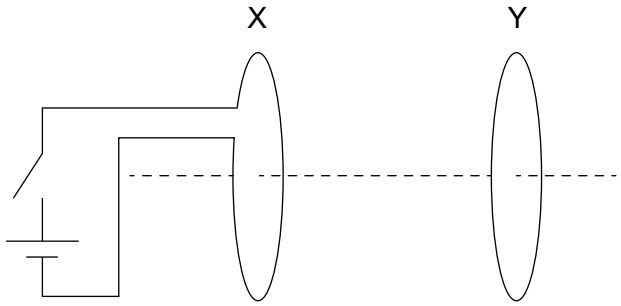
A. 0

B. $\frac{10\sqrt{2}}{2}$ A

C. 10 A

D. $10\sqrt{2}$ A

**36.** A coil X is connected to a cell and a switch that is initially open. Coil Y has its plane parallel to X. X and Y have a common axis.




When the switch is closed a force *F* acts on Y due to X.

What is the variation with time of *F* and what is the direction of *F*?

| | **Variation with time of *F*** | **Direction of *F*** |
|---|---|---|
| A. | Increases initially reaching a constant value | Towards X |
| B. | Increases initially reaching a constant value | Away from X |
| C. | Increases initially and then decreases | Towards X |
| D. | Increases initially then decreases | Away from X |

**37.** What is evidence for the wave nature of an electron and evidence for the particulate nature of light?

| | **Evidence for wave nature of an electron** | **Evidence for the particulate nature of light** |
|---|---|---|
| A. | Electron diffraction | Photoelectric effect |
| B. | Electron diffraction | Polarization |
| C. | Photoelectric effect | Polarization |
| D. | Photoelectric effect | Photoelectric effect |

**38.** When alpha particle scattering experiments were carried out with high-energy alpha particles, deviations from Rutherford scattering were observed.

What was deduced as a result of this observation?

A. The size of the alpha particle

B. The size of the nucleus

C. The nature of the electrostatic field inside the nucleus

D. The nature of the weak nuclear force within the nucleus

**39.** The uncertainty principle links pairs of quantities.

What are the pairs according to the principle?

| | **Pair 1** | **Pair 2** |
|---|---|---|
| A. | Energy and speed | Momentum and force |
| B. | Position and energy | Time and momentum |
| C. | Speed and momentum | Force and energy |
| D. | Energy and time | Position and momentum |

**40.** Alpha decay occurs when an alpha particle undergoes quantum mechanical tunnelling through the potential barrier of the nucleus.

Three quantities involved in alpha emission from a particular nucleus are:

I. The height of the potential barrier

II. The radioactive decay constant for alpha emission

III. The width of the potential barrier

The probability of alpha tunnelling is determined by

A. I and II only

B. I and III only

C. II and III only

D. I, II and III