Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 1A

29 April 2025

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

2 hours [Paper 1A and Paper 1B]

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for paper 1A is **[40 marks]**.
- The maximum mark for paper 1A and paper 1B is **[60 marks]**.

2225–6719
17 pages

1. A car decelerates uniformly to rest. From an initial velocity v to a velocity $\frac{v}{2}$, it covers a distance d. How much further does it travel before coming to rest?

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

B. $\frac{d}{3}$

C. $\frac{d}{2}$

D. d

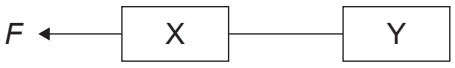
2. Two balls, P and Q, are projected from the edge of a cliff. P is projected horizontally at speed v and Q is projected vertically upwards at the same speed. The time taken for P to reach the ground is t_P and the speed at impact with the ground is v_P. **Air resistance is negligible**.

What is the time taken to reach the ground and the speed at impact with the ground for Q?

	Time taken	Speed at impact
A.	t_P	v_P
B.	t_P	Greater than v_P
C.	Greater than t_P	v_P
D.	Greater than t_P	Greater than v_P

3. Two identical blocks, X and Y, each of mass 2.0 kg are connected by a string. They move on the same surface.

A force F accelerates the blocks at $0.5\,m\,s^{-2}$. The frictional force on block X is 4.0 N.



What is the tension in the string?

A. 1 N

B. 2 N

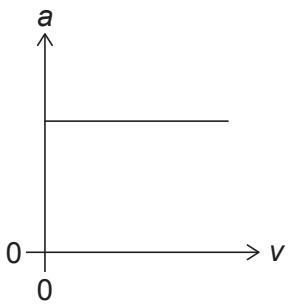
C. 5 N

D. 10 N

4. A raindrop falls from rest through air with velocity v and acceleration a.

Which graph best represents the variation of a with v?

A.



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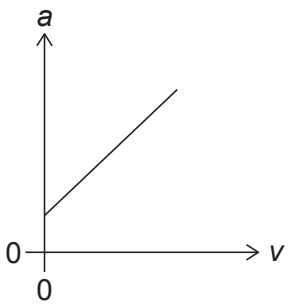

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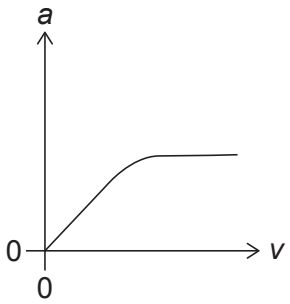

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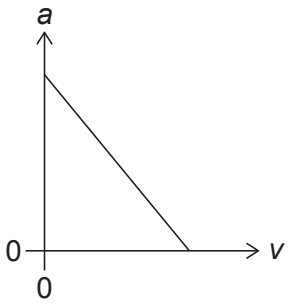


5. A ball of mass m collides with a stationary ball of mass $3m$. After colliding, the two balls move together.

What is the percentage loss in kinetic energy of the system?

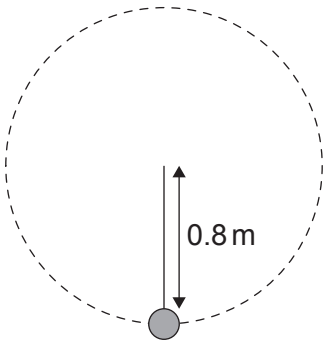
A. 0 %

B. 25 %

C. 50 %

D. 75 %

6. A ball of mass 0.4 kg is attached to a string of length 0.8 m. The ball is rotated in a vertical circle such that the speed at the lowest position is $6.0\,\text{m}\,\text{s}^{-1}$.



What is the tension in the string when the ball is at the lowest position?

A. 4.0 N

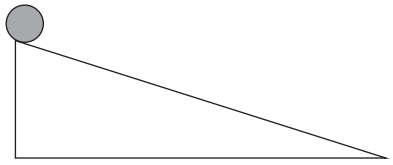
B. 14 N

C. 18 N

D. 22 N

7. A solid cylinder of mass m and radius r is released from rest on an inclined plane. The cylinder rolls without slipping.

The moment of inertia of the cylinder is $\frac{1}{2}mr^2$. The speed when it reaches the bottom of the inclined plane is v.



What is the vertical height from which the cylinder was released?

A. $\frac{v^2}{g}$

B. $\frac{3v^2}{4g}$

C. $\frac{v^2}{2g}$

D. $\frac{v^2}{4g}$

8. Two spheres, X and Y, are spinning with the same rotational kinetic energy. The moment of inertia of X is I_X and that of Y is I_Y.

What is $\frac{\text{angular momentum of X}}{\text{angular momentum of Y}}$?

A. $\sqrt{\frac{I_X}{I_Y}}$

B. $\sqrt{\frac{I_Y}{I_X}}$

C. $\frac{I_X}{I_Y}$

D. $\frac{I_Y}{I_X}$

9. A pendulum has a period of 3.0 s as measured in its inertial frame of reference. An observer is moving with a speed of 0.80 *c* with respect to the pendulum's frame.

What is the period of the pendulum measured by the observer?

A. 8.3 s

B. 5.0 s

C. 1.8 s

D. 1.1 s

10. A liquid is heated at a constant rate in an open container. The temperature of the liquid rises by 0.50 °C per second until it boils. In a period of 10 minutes after reaching boiling point, half the mass of the liquid has vaporized.

What is $\frac{\text{specific heat capacity of the liquid}}{\text{specific latent heat of vaporization of the liquid}}$?

A. $\frac{1}{600}$

B. $\frac{1}{300}$

C. $\frac{1}{10}$

D. $\frac{1}{5}$

11. Star X has a surface temperature T, luminosity L and radius R.

The luminosity of star Y is $4L$ and the surface temperature is $2T$.

What is the radius of star Y?

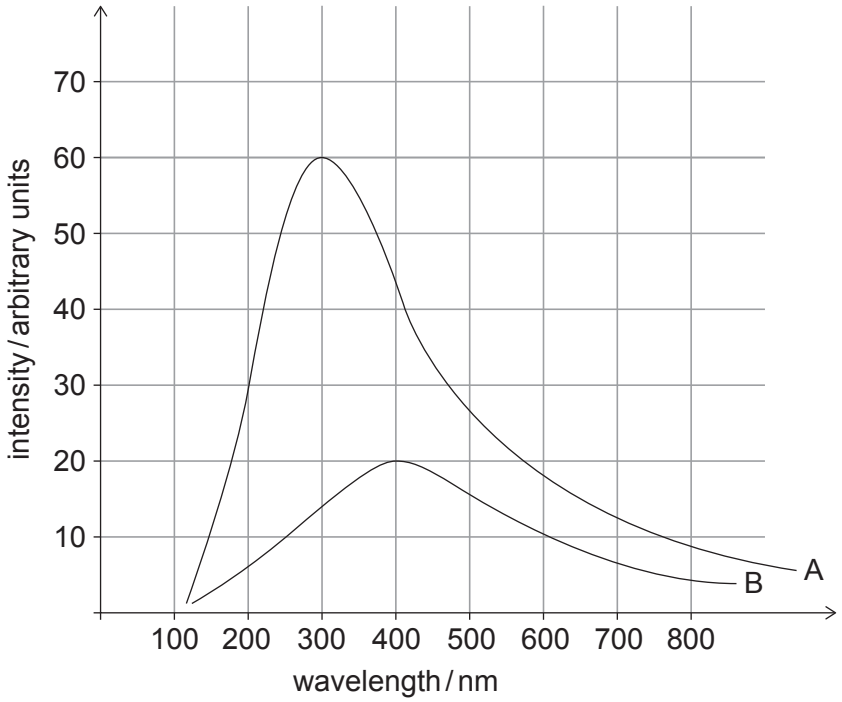
A. $\frac{R}{2}$

B. $\frac{R}{\sqrt{2}}$

C. $2R$

D. $4R$

12. The black-body radiation curves for two objects A and B are shown.



What is $\frac{\text{temperature of A}}{\text{temperature of B}}$?

A. $\frac{1}{3}$

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

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

D. 3

13. The albedo of a planet with no atmosphere is 0.25. The reflected intensity is $240\,W\,m^{-2}$.

What is the outgoing radiated intensity?

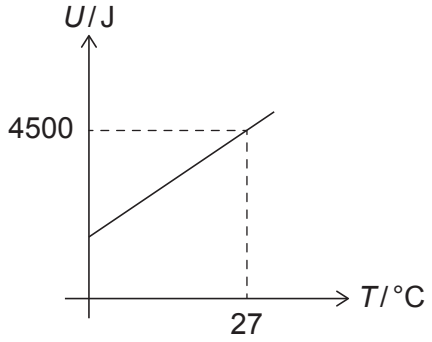
A. $180\,W\,m^{-2}$

B. $300\,W\,m^{-2}$

C. $720\,W\,m^{-2}$

D. $960\,W\,m^{-2}$

14. The graph shows the variation of the internal energy U with temperature T for a sample of an ideal monatomic gas. R is the gas constant.



How many moles of the gas are in the sample?

A. $\frac{500}{3R}$

B. $\frac{15}{R}$

C. $\frac{1000}{9R}$

D. $\frac{10}{R}$

15. 75 J of thermal energy is transferred to an ideal monatomic gas at a constant pressure of 1.0×10^5 Pa. The volume of the gas increases from $2.7 \times 10^{-3}\,m^3$ to $3.0 \times 10^{-3}\,m^3$.

What is the change in the internal energy of the gas?

A. 45 J

B. 105 J

C. –45 J

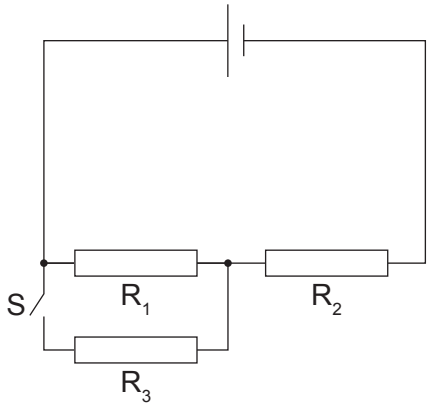
D. –105 J

16. A gas is compressed at constant temperature.

What are the changes in entropy of the gas and its surroundings during the compression?

	Entropy of the gas	Entropy of surroundings
A.	Increases	Increases
B.	Increases	Decreases
C.	Decreases	Increases
D.	Decreases	Decreases

17. Three identical resistors, R_1, R_2 and R_3, each of resistance $2\,\Omega$, are connected to a cell of negligible internal resistance as shown. When switch S is open, the power dissipated by R_1 is 18 W.



What is the power dissipated by R_1 when S is closed?

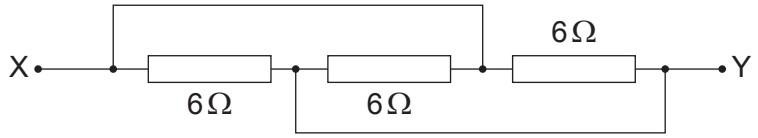
A. 8 W

B. 16 W

C. 18 W

D. 36 W

18. Three identical resistors of 6 Ω are arranged as shown.



What is the resistance between X and Y?

A. 2 Ω

B. 4 Ω

C. 9 Ω

D. 18 Ω

19. A simple pendulum oscillates with period T on Earth. The mass of the pendulum is doubled and oscillates on the Moon where the acceleration due to gravity is $\frac{1}{6}$ that of Earth. The length of the pendulum stays the same.

What is the period of the pendulum on the Moon?

A. $\sqrt{12}\,T$

B. $\sqrt{6}\,T$

C. $\sqrt{3}\,T$

D. $\sqrt{2}\,T$

20. A body of mass 2.0 kg undergoes simple harmonic motion with a maximum displacement of 0.5 m. The period of oscillation of the body is $\frac{\pi}{4}$ s.

What is the total energy of the body?

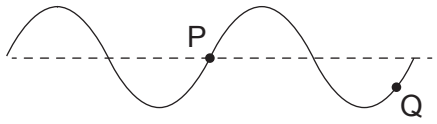
A. 2 J

B. 8 J

C. 16 J

D. 32 J

21. The diagram below shows a snapshot of a transverse wave on a rope. Points P and Q are two points on the rope at a position shown in the diagram. The subsequent motion of P is upwards.

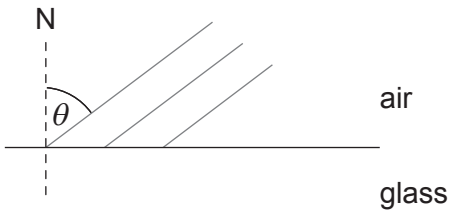


What is the direction of motion of Q and the direction of travel of the wave?

	Direction of motion of Q	Direction of travel of the wave
A.	Upwards	Left to right
B.	Downwards	Left to right
C.	Upwards	Right to left
D.	Downwards	Right to left

22. The diagram shows wavefronts of light incident on an air–glass boundary.

The angle between the incident wavefront and the normal, N, is θ.



Which of the following gives the correct expression for the refractive index of the glass, where r is the angle of refraction?

A. $\dfrac{\sin\theta}{\sin r}$

B. $\dfrac{\sin(90-\theta)}{\sin r}$

C. $\dfrac{\sin r}{\sin\theta}$

D. $\dfrac{\sin r}{\sin(90-\theta)}$

23. S_1 and S_2 are two coherent sound sources with no phase difference. The wavelength of both waves is 0.20 m. P is a point 6.0 m away from S_1 and 6.5 m away from S_2 respectively. At P the amplitude of the wave from S_1 is x_0 and from S_2 is $2x_0$.

What is the resultant amplitude at P?

A. 0

B. x_0

C. $2x_0$

D. $3x_0$

24. A parallel beam of monochromatic light of wavelength λ passes through a rectangular slit of width *b* and is incident on a screen at a distance x from the slit.

What is the width of the central maximum of the diffraction pattern on the screen?

A. $\frac{\lambda}{b}$

B. $\frac{2\lambda}{b}$

C. $\frac{\lambda x}{b}$

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

25. The frequency of the first harmonic for a pipe open at both ends is f. The length of the pipe is 0.4 m. A second pipe, open at one end and closed at the other, produces a first harmonic of the same frequency f.

What is the length of the second pipe?

A. 0.1 m

B. 0.2 m

C. 0.4 m

D. 0.8 m

26. The relationship between the period of a planet's orbit T and the distance to the Sun R can be expressed as $T^n \propto R^m$ where n and m are constants.

What is a possible pair of values for n and m?

	n	m
A.	1.0	3.0
B.	1.0	1.5
C.	2.0	1.5
D.	2.0	1.0

27. Point X is at a distance d from the centre of Earth. d is larger than the radius of Earth. The gravitational field strength at X is g_X. Point Y is at a distance $3d$ from the centre of Earth.

What is the difference in the magnitude of gravitational field strengths between X and Y?

A. $\frac{8g_X}{9}$

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

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

D. $\frac{g_X}{9}$

28. The work done per unit mass to move a body from infinity to a point P in a gravitational field is the

A. gravitational field strength at P.

B. gravitational force at P.

C. gravitational potential energy at P.

D. gravitational potential at P.

29. In a Millikan's experiment, an oil drop is stationary between two parallel plates. A second oil drop of the same density, between the same plates, has twice the charge and twice the radius of the first oil drop.

The second oil drop will initially

A. be stationary.

B. move with constant velocity downwards.

C. accelerate upwards.

D. accelerate downwards.

30. Two isolated point charges, X of charge $+Q$ and Y of charge $+2Q$, are separated by a distance $3d$. P is a point d from X and $2d$ from Y respectively.

What is the net electric field strength at P?

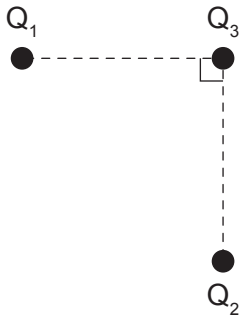
A. 0

B. $\frac{kQ}{2d^2}$

C. $\frac{3kQ}{4d^2}$

D. $\frac{3kQ}{2d^2}$

31. Two isolated positive point charges Q_1 and Q_2 are equidistant from a third charge Q_3 as shown. The force on Q_3 due to Q_1 is F. The force on Q_3 due to Q_2 is $2F$.



What is the resultant force on Q_3?

A. F

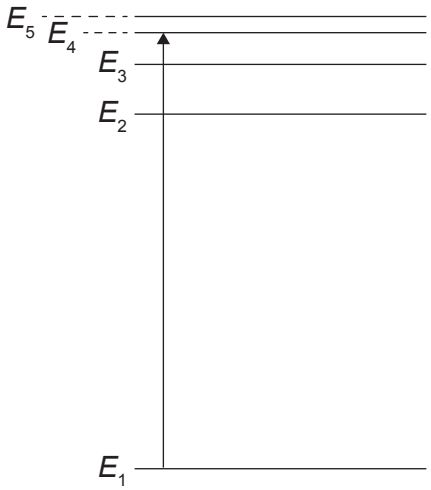
B. $\sqrt{3}F$

C. $\sqrt{5}F$

D. $3F$

32. The energy levels of an atom in which an electron transitions from E_1 to E_4 are shown. E_1 is the ground state.

diagram to scale



How many different wavelengths can be emitted when electrons return to the ground state from E_4?

A. 1

B. 3

C. 6

D. 8

33. The nucleus of an element X has radius R and density ρ.

The nucleon number of an element Y is 8 times that of X.

What is the radius and density of the nucleus of Y?

	Radius of nucleus of Y	Density of nucleus of Y
A.	$8R$	8ρ
B.	$2R$	8ρ
C.	$8R$	ρ
D.	$2R$	ρ

34. Which of the following expressions gives the de Broglie wavelength, in metres, of a tennis ball of mass 0.06 kg and kinetic energy 3 J?

A. $\frac{h}{3}$

B. $\frac{h}{0.6}$

C. $\frac{h}{(0.6)^2}$

D. $\frac{h}{0.06}$

35. Thorium-232 ($^{232}_{90}\text{Th}$) is an unstable nuclide. It decays by emitting an alpha particle followed by a beta minus (β^-) particle.

What is the number of protons and neutrons in the final nuclide?

	Number of protons	Number of neutrons
A.	87	139
B.	87	141
C.	89	139
D.	89	141

36. A pure sample of radon-222 decays into polonium with a half-life of 4 days. A measurement is made of its radioactivity. The initial count rate is 420 counts per second. The measured background count is 20 counts per second.

What is the measured count rate after 8 days?

A. 85

B. 100

C. 105

D. 120

37. Which component is responsible for slowing down neutrons in a nuclear reactor to increase the likelihood of nuclear fission?

A. Moderator

B. Control rods

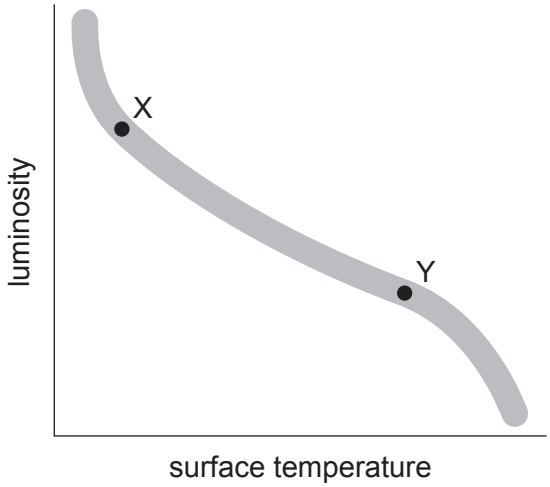
C. Fuel rods

D. Heat exchanger

38. Which of the following temperature and density conditions are necessary for fusion to occur in a star?

	Temperature of the star	**Density of the star**
A.	High	High
B.	High	Low
C.	Low	High
D.	Low	Low

39. The HR diagram shows two stars, X and Y.



Three statements are made about star X and star Y.

I. Star X is hotter than star Y.

II. Star X has a larger radius than star Y.

III. Star X is more luminous than star Y.

Which of the statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

40. X is a star of luminosity *L* and apparent brightness *b*. Y is a star of luminosity *L* and apparent brightness 2*b*.

As viewed from Earth, what is $\frac{\text{parallax angle subtended by X}}{\text{parallax angle subtended by Y}}$?

A. $\frac{1}{\sqrt{2}}$

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

C. $\sqrt{2}$

D. 2