Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 1

Thursday 4 November 2021 (afternoon)

45 minutes

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 **[30 marks]**.

8821 – 6504

1. Which is a vector quantity?

A. Acceleration

B. Energy

C. Pressure

D. Speed

2. A ball of mass (50 ± 1) g is moving with a speed of $(25 \pm 1)\,m\,s^{-1}$. What is the fractional uncertainty in the momentum of the ball?

A. 0.02

B. 0.04

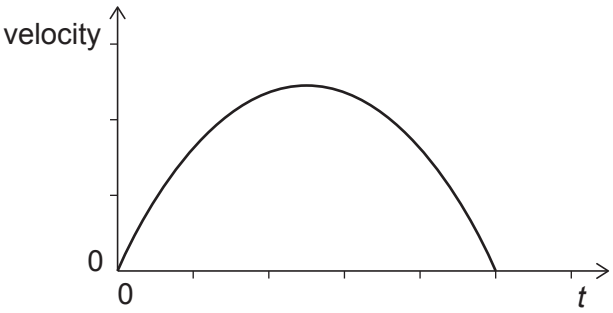
C. 0.06

D. 0.08

$p = mv$

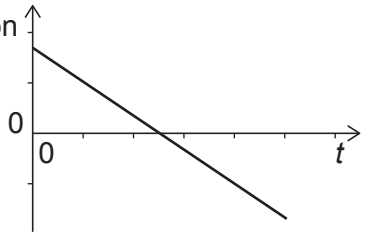
$\frac{1}{50} + \frac{1}{25} = \frac{2}{100} + \frac{4}{100} = \frac{6}{100}$

3. The graph shows the variation with time t of the velocity of an object.

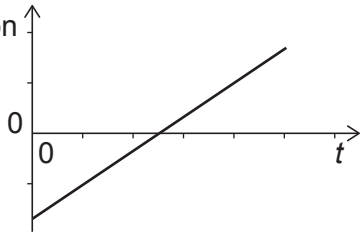


What is the variation with time t of the acceleration of the object?

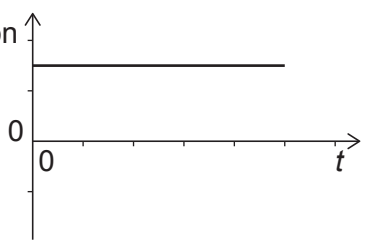
A.



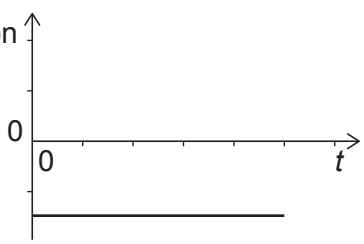
B.



C.



D.



4. A ball is thrown vertically downwards with an initial speed of $4.0\,m\,s^{-1}$. The ball hits the ground with a speed of $16\,m\,s^{-1}$. Air resistance is negligible. What is the time of fall and what is the distance travelled by the ball?

	Time of fall / s	Distance / m
A.	1.0	10
B.	1.0	12
C.	1.2	10
D.	1.2	12

$s =$
$u = 4\,ms^{-1}$
$v = 16\,ms^{-1}$
$a = 10\,ms^{-2}$
$t = 1.2$ secs

$\frac{v-u}{t} = a$

$\frac{16-4}{t} = 10$

$12 = 10t$

$1.2 = t$

$v^2 = u^2 + 2as$

$16^2 = 4^2 + 2(10)s$

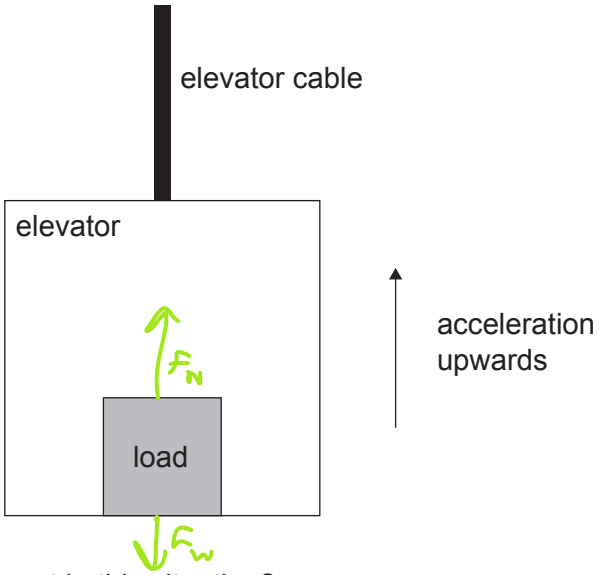
$16^2 = 16 + 20s$

$256 = 16 + 20s$

$240 = 20s$

$12 = s$

5. An elevator (lift) and its load accelerate vertically upwards.



Which statement is correct in this situation?

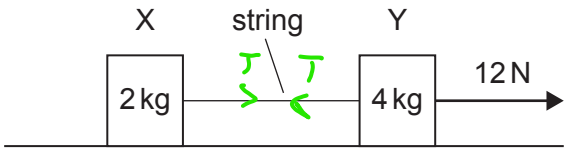
A. The net force on the load is zero.

B. The tension in the cable is equal but opposite to the combined weight of the elevator and its load.

C. The normal reaction force on the load is equal but opposite to the force on the elevator from the load.

D. The elevator and its load are in translational equilibrium.

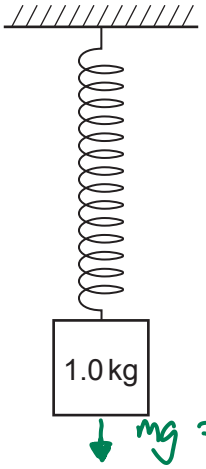
6. X and Y are two objects on a frictionless table connected by a string. The mass of X is 2 kg and the mass of Y is 4 kg. The mass of the string is negligible. A constant horizontal force of 12 N acts on Y.



What are the acceleration of Y and the magnitude of the tension in the string?

	Acceleration of Y / m s^{-2}	Tension in the string / N
A.	2	4
B.	2	6
C.	3	4
D.	3	6

7. An object of mass 1.0 kg hangs at rest from a spring. The spring has a negligible mass and the spring constant k is 20 N m^{-1}.



What is the elastic potential energy stored in the spring?

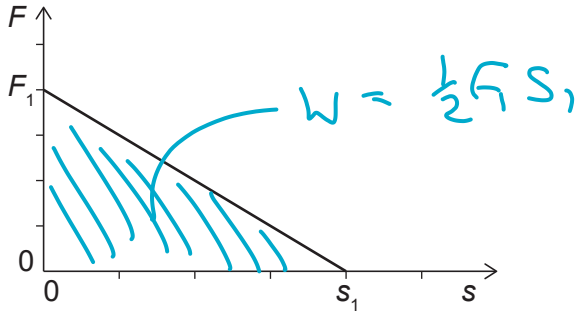
A. 1.0 J

B. 2.5 J

C. 5.0 J

D. 10 J

8. A net force F acts on an object of mass m that is initially at rest. The object moves in a straight line. The variation of F with the distance s is shown.



What is the speed of the object at the distance s_1?

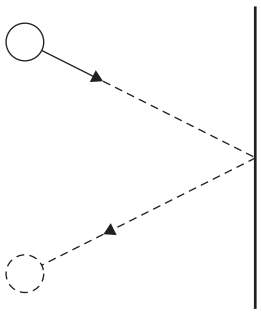
A. $\sqrt{\frac{F_1 s_1}{2m}}$

B. $\sqrt{\frac{F_1 s_1}{m}}$

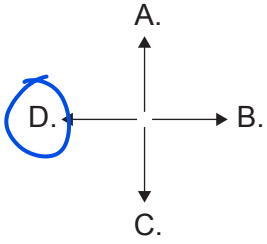
C. $\sqrt{\frac{2F_1 s_1}{m}}$

D. $\sqrt{\frac{4F_1 s_1}{m}}$

9. A ball rolls on the floor towards a wall and rebounds with the same speed and at the same angle to the wall.



What is the direction of the impulse applied to the ball by the wall?



10. A liquid is vaporized to a gas at a constant temperature.

Three quantities of the substance are the

I. total intermolecular potential energy

II. root mean square speed of the molecules ← KE => Temp : but temp constant

III. average distance between the molecules.

Which quantities are **greater** for the substance in the gas phase compared to the liquid phase?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. A mass m of a liquid of specific heat capacity c flows every second through a heater of power P. What is the difference in temperature between the liquid entering and leaving the heater?

A. $\frac{mc}{P}$

B. $273 + \frac{mc}{P}$

C. $\frac{P}{mc}$

D. $273 + \frac{P}{mc}$

$\frac{P}{t} = mc\Delta T$

$\frac{P}{mc} = \Delta T$

12. A fixed mass of an ideal gas has a volume of V, a pressure of p and a temperature of 30 °C. The gas is compressed to the volume of $\frac{V}{6}$ and its pressure increases to $12p$. What is the new temperature of the gas?

303°K

A. 15 °C

B. 60 °C

C. 333 °C

D. 606 °C

$pV \propto T$

$\frac{12pV}{6}$

$2pV$ so $T \times 2 = 606K \Rightarrow 333°C$

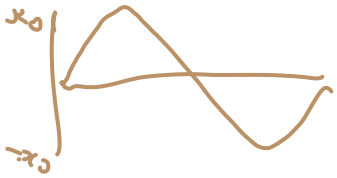
13. A particle undergoes simple harmonic motion of amplitude x_0 and frequency f. What is the average speed of the particle during one oscillation?

A. 0

B. $f x_0$

C. $2 f x_0$

D. $4 f x_0$



Total travel is $4x_0$

$v = 4 f x_0$

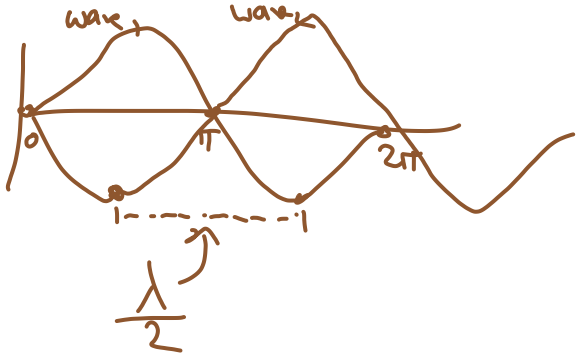
14. A travelling wave on the surface of a lake has wavelength λ. Two points along the wave oscillate with the phase difference of π. What is the smallest possible distance between these two points?

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

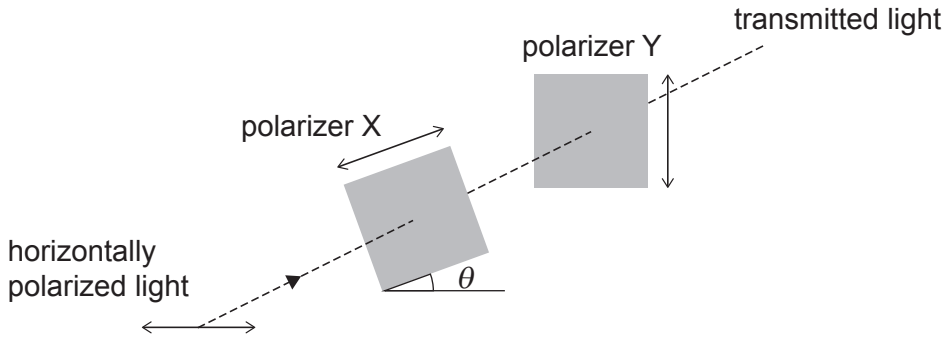
B. $\frac{\lambda}{2}$

C. λ

D. 2λ



15. Horizontally polarized light is incident on a pair of polarizers X and Y. The axis of polarization of X makes an angle θ with the horizontal. The axis of polarization of Y is vertical.



What is θ so that the intensity of the light transmitted through Y is a maximum?

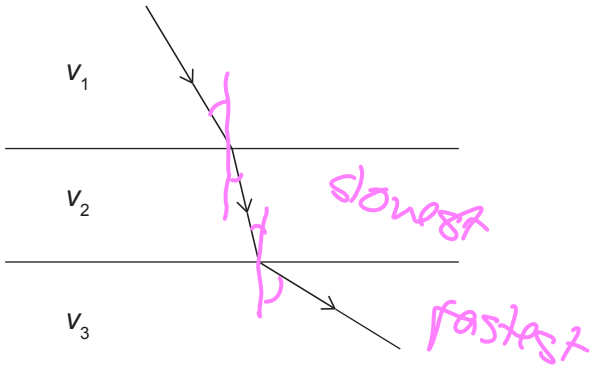
A. 0°

B. 45°

C. 90°

D. 180°

16. A ray of monochromatic light is incident on the parallel interfaces between three media. The speeds of light in the media are v_1, v_2 and v_3.



What is correct about the speeds of light in the media?

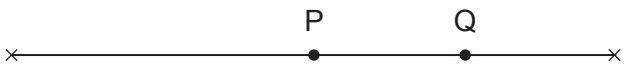
A. $v_3 < v_1 < v_2$

B. $v_3 < v_2 < v_1$

C. $v_2 < v_3 < v_1$

D. $v_2 < v_1 < v_3$

17. A string is fixed at both ends. P and Q are two particles on the string.



The first harmonic standing wave is formed in the string. What is correct about the motion of P and Q?

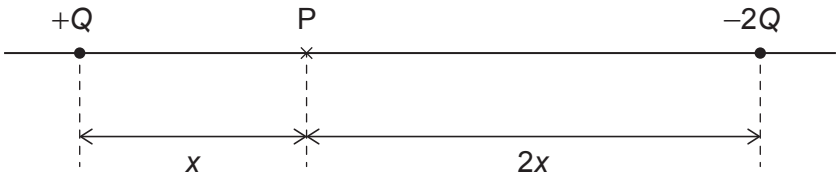
A. P is a node and Q is an antinode.

B. P is an antinode and Q is a node.

C. P and Q oscillate with the same amplitude.

D. P and Q oscillate with the same frequency.

18. A charge $+Q$ and a charge $-2Q$ are a distance $3x$ apart. Point P is on the line joining the charges, at a distance x from $+Q$.



The magnitude of the electric field produced at P by the charge $+Q$ alone is E.

What is the total electric field at P?

A. $\frac{E}{2}$ to the right

B. $\frac{E}{2}$ to the left

C. $\frac{3E}{2}$ to the right

D. $\frac{3E}{2}$ to the left

19. Two wires, X and Y, are made of the same material and have equal length. The diameter of X is twice that of Y.

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

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

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

C. 2

D. 4

20. An electric motor of efficiency 0.75 is connected to a power supply with an emf of 20 V and negligible internal resistance. The power output of the motor is 120 W. What is the average current drawn from the power supply?

A. 3.1A

B. 4.5A

C. 6.0A

D. 8.0A

$P = IV$

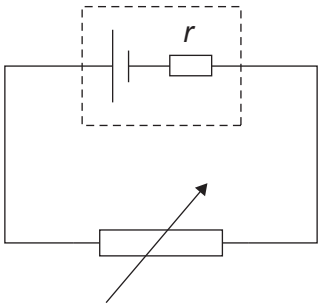
$160 = 20I$

$8 = I$

$120W = 75\%$

$160W = 100\%$

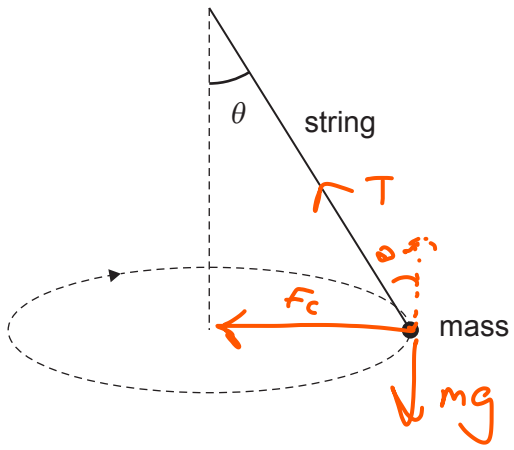
21. A variable resistor is connected in series to a cell with internal resistance r as shown.



The resistance of the variable resistor is increased. What happens to the power dissipated in the cell and to the terminal potential difference of the cell?

	Power dissipated in the cell	**Terminal potential difference of the cell**
A.	decreases	increases
B.	increases	increases
C.	decreases	decreases
D.	increases	decreases

22. A mass at the end of a string is moving in a horizontal circle at constant speed. The string makes an angle θ to the vertical.



What is the magnitude of the acceleration of the mass?

A. g

B. $g\sin\theta$

C. $g\cos\theta$

D. $g\tan\theta$

$\tan\theta = \frac{F_c}{mg}$

$g\tan\theta = \frac{mv^2}{mr}$

$g\tan\theta = a$

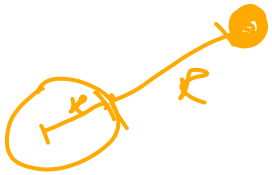
23. The gravitational field strength at the surface of a planet of radius R is g. A satellite is moving in a circular orbit a distance R above the surface of the planet. What is the magnitude of the acceleration of the satellite?

A. 0

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

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

D. g



$g = \frac{GM}{r^2}$

$g = \frac{GM}{(2R)^2} = \frac{GM}{4R^2}$

$= \frac{1}{4}g$

24. A pure sample of radioactive nuclide X decays into a stable nuclide Y.

What is $\frac{\text{number of atoms of Y}}{\text{number of atoms of X}}$ after two half-lives?

A. 1

B. 2

C. 3

D. 4

X = 100% → 50% → 25%

Y = 0% → 50% → 75%

$\frac{75}{25} = 3$

25. The mass of a nucleus of iron-56 ($^{56}_{26}\text{Fe}$) is M.

What is the mass defect of the nucleus of iron-56?

A. $M - 26m_p - 56m_n$

B. $26m_p + 30m_n - M$

C. $M - 26m_p - 56m_n - 26m_e$

D. $26m_p + 30m_n + 26m_e - M$

26. A proton collides with an electron. What are the possible products of the collision?

A. Two neutrons

B. Neutron and positron

C. Neutron and antineutrino

D. Neutron and neutrino

27. The Higgs boson was discovered in the Large Hadron Collider at CERN. Which statements are correct about the discovery of the Higgs boson?

I. It was independent of previous theoretical work.

II. It involved analysing large amounts of experimental data.

III. It was consistent with the standard model of particle physics.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

28. A fuel has mass density ρ and energy density u. What mass of the fuel has to be burned to release thermal energy E?

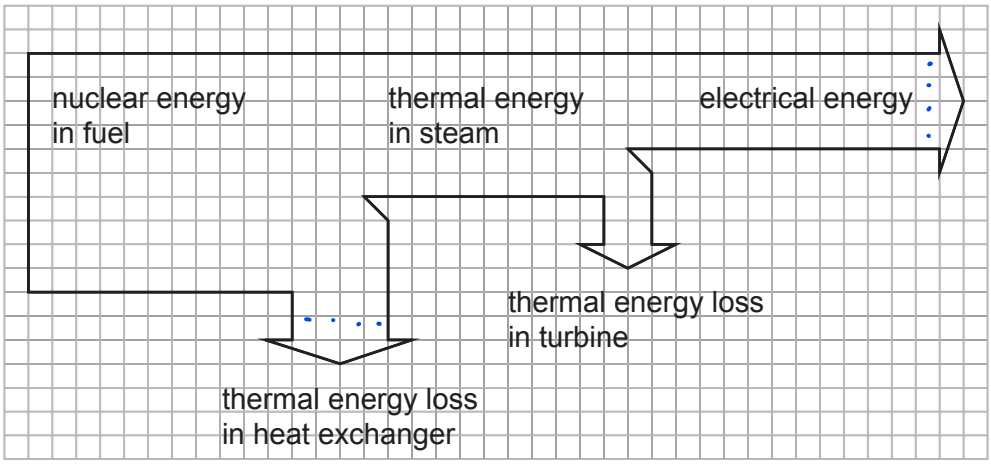
A. $\frac{\rho E}{u}$

B. $\frac{uE}{\rho}$

C. $\frac{\rho u}{E}$

D. $\rho u E$

29. The Sankey diagram shows the energy transfers in a nuclear power station.



Electrical power output of the power station is 1000 MW.

What is the thermal power loss in the heat exchanger?

A. 500 MW

B. 1000 MW

C. 1500 MW

D. 2500 MW

30. Which is correct for a black-body radiator?

A. The power it emits from a unit surface area depends on the temperature only.

B. It has an albedo of 1.

C. It emits monochromatic radiation whose wavelength depends on the temperature only.

D. It emits radiation of equal intensity at all wavelengths.

References: