Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 1

Monday 9 November 2015 (morning)

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]**.

8815 – 6501

1. Which of the following is a derived unit?

A. Mole

B. Kelvin

C. Coulomb

D. Ampere

2. An object is dropped from rest. Air resistance is **not** negligible. What is the acceleration of the object at the start of the motion?

A. Zero

B. Increasing

C. Decreasing

D. Constant

3. Which of the following is proportional to the net external force acting on a body?

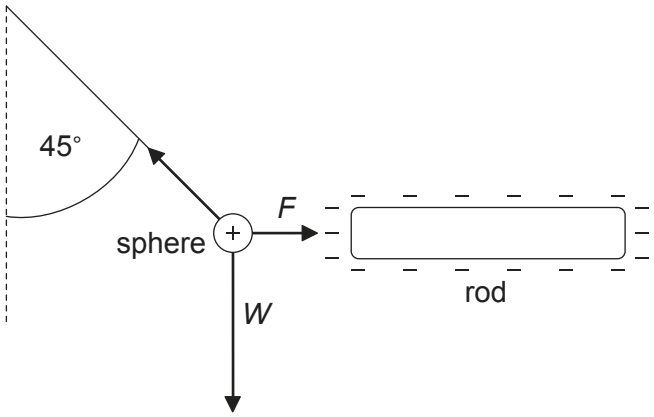
A. Speed

B. Velocity

C. Rate of change of speed

D. Rate of change of velocity

4. A small positively charged sphere is suspended from a thread and placed close to a negatively charged rod. When the thread is at 45° to the vertical the system is in equilibrium. The weight of the sphere is *W* and the magnitude of the electrostatic force between the rod and the sphere is *F*.



(not to scale)

What is the magnitude of *W* compared with the magnitude of *F*?

A. $W = \sqrt{2}F$

B. $F < W < \sqrt{2}F$

C. $W = F$

D. $W > F$

5. A heat engine does 300 J of work during one cycle. In this cycle 900 J of energy is wasted. What is the efficiency of the engine?

A. 0.25

B. 0.33

C. 0.50

D. 0.75

6. A student throws a stone with velocity v at an angle θ to the vertical from the surface of a lake. Air resistance can be ignored. The acceleration due to gravity is g.

What is the time taken for the stone to hit the surface of the lake?

A. $\frac{v\sin\theta}{g}$

B. $\frac{v\cos\theta}{g}$

C. $\frac{2v\sin\theta}{g}$

D. $\frac{2v\cos\theta}{g}$

7. When 1800 J of energy is supplied to a mass m of liquid in a container, the temperature of the liquid and the container changes by 10 K. When the mass of the liquid is doubled to $2m$, 3000 J of energy is required to change the temperature of the liquid and container by 10 K. What is the specific heat capacity of the liquid in $\text{J kg}^{-1}\text{ K}^{-1}$?

A. $\frac{60}{m}$

B. $\frac{120}{m}$

C. $\frac{180}{m}$

D. $\frac{240}{m}$

8. An ideal gas and a solid of the same substance are at the same temperature. The average kinetic energy of the gas molecules is E_g and the average kinetic energy of the solid molecules is E_s. What is the comparison between E_g and E_s?

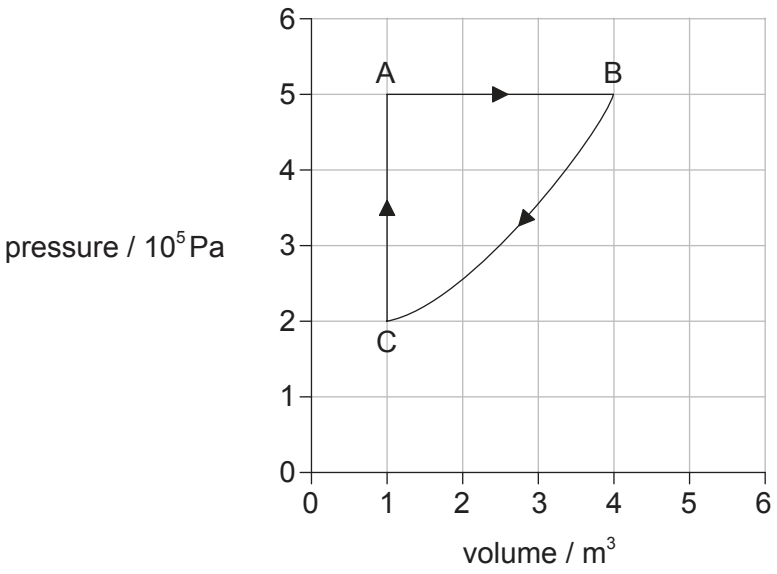
A. E_g is less than E_s.

B. E_g equals E_s.

C. E_g is greater than E_s.

D. The relationship between E_g and E_s cannot be determined.

9. The graph shows how the volume of a system varies with pressure during a cycle ABCA.



What is the work done in joules during the change AB?

A. 15×10^5

B. 9.0×10^5

C. 4.5×10^5

D. 0

10. A system consists of a refrigerator with its door open operating in a thermally insulated room. What are the change in the entropy of the system and the change in temperature of the room?

	Entropy change of system	Temperature change of room
A.	decreases	decreases
B.	decreases	increases
C.	increases	decreases
D.	increases	increases

11. A transverse travelling wave has an amplitude x_0 and wavelength λ. What is the minimum distance between a crest and a trough measured in the direction of energy propagation?

A. $2x_0$

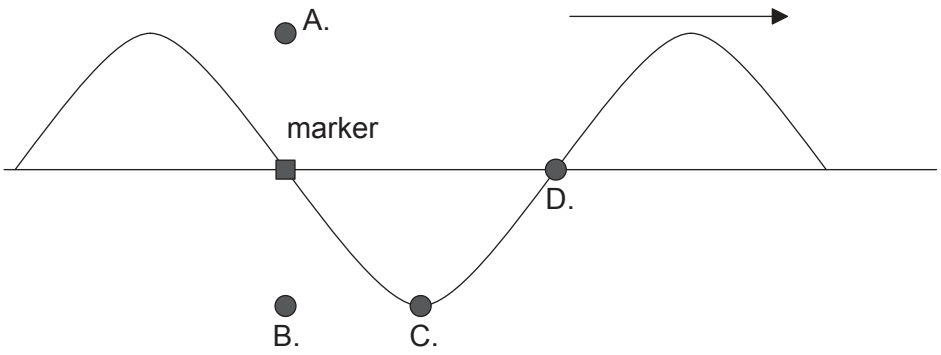
B. x_0

C. λ

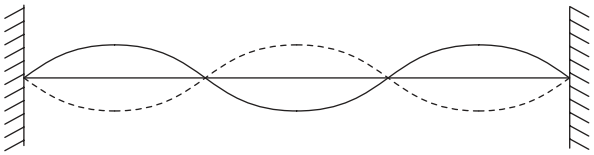
D. $\frac{\lambda}{2}$

12. A wave on a string travels to the right as shown. The frequency of the wave is f. At time $t = 0$, a small marker on the string is in the position shown.

What is the position of the marker at $t = \frac{1}{4f}$?



13. A standing (stationary) wave is set up on a string at a particular frequency as shown.



How many nodes will be on the string if the frequency is doubled but nothing else is changed?

A. 2

B. 3

C. 7

D. 8

14. A source emits sound of wavelength λ_0 and wave speed v_0. A stationary observer hears the sound as the source moves away. What are the wavelength of the sound and the wave speed of the sound as measured by the stationary observer?

	Wavelength	Wave speed
A.	less than λ_0	equal to v_0
B.	greater than λ_0	equal to v_0
C.	less than λ_0	less than v_0
D.	greater than λ_0	less than v_0

15. Electromagnetic waves pass through a slit in a metal plate with minimal diffraction. The slit has a width of 0.25 m. What is the wavelength of the waves?

A. Much less than 0.25 m

B. Between 0.10 m and 0.40 m

C. Equal to 0.25 m

D. Much greater than 0.25 m

16. A radio telescope has a circular collecting dish of diameter 5.0 m. It is used to observe two distant galaxies that are both emitting electromagnetic radiation of wavelength 20 cm. The images of the galaxies are just resolved by the telescope. What is the angle subtended by the galaxies at the telescope?

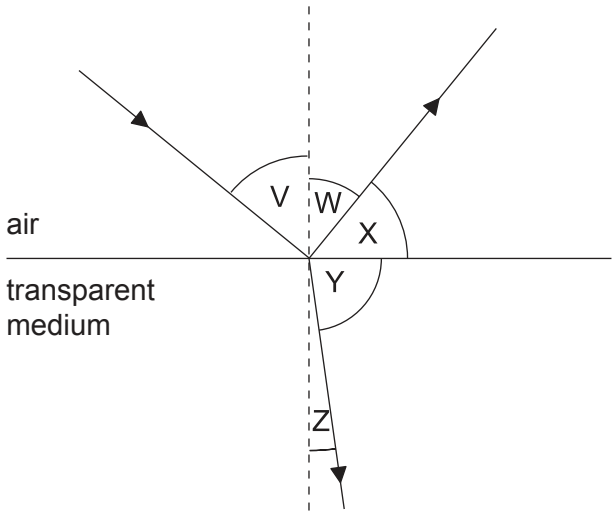
A. 0.05 rad

B. 0.3 rad

C. 5 rad

D. 30 rad

17. Light is incident from air on the surface of a transparent medium.



(angles not drawn to scale)

When V is equal to the Brewster angle, which angle is equal to 90°?

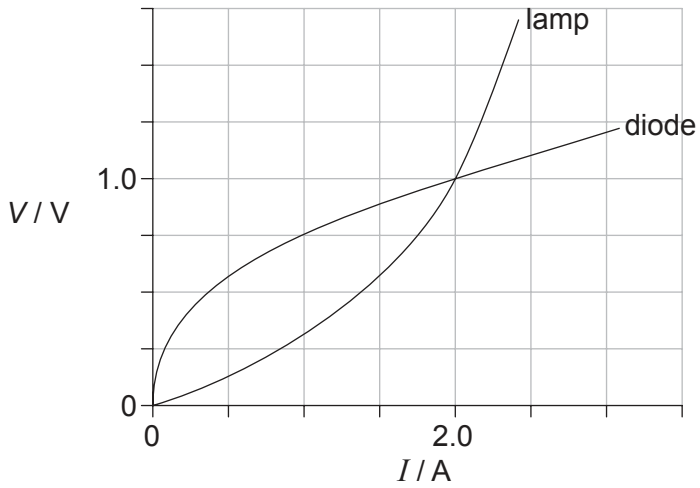
A. V + W

B. W only

C. X + Y

D. Z only

18. A filament lamp and a semiconducting diode have the voltage–current (V–I) characteristics shown and are connected in parallel.



What is the resistance of the lamp and the resistance of the diode when the current in each device is 2.0A?

	Resistance of lamp / Ω	Resistance of diode / Ω
A.	1.0	0.25
B.	1.0	0.50
C.	0.50	0.25
D.	0.50	0.50

19. A cylindrical resistor of length l is made from a metal of mass m. It has a resistance R.

Two resistors, each of length $2l$ and mass $\frac{m}{2}$, are then created from the same volume of the metal.

What is the resistance of the two resistors when connected in parallel?

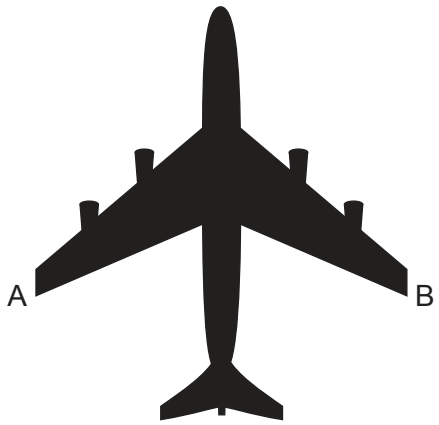
A. R

B. $2R$

C. $4R$

D. $8R$

20. An aircraft with a wing span of 50 m flies horizontally at a speed of 200 m s^{-1}. The vertical component of the Earth's magnetic field at the plane's position is 10 μT.



What electromotive force (emf) is induced between points A and B on the aircraft?

A. 0.1 V

B. 1 V

C. 10 V

D. 100 V

21. An alternating current is sinusoidal and has a maximum value of 1.5 A. What is the approximate value of the root mean squared (rms) current?

A. 2.3 A

B. 1.5 A

C. 1.0 A

D. 0.75 A

22. What is the correct definition of gravitational field strength?

A. The mass per unit weight

B. The weight of a small test mass

C. The force acting on a small test mass

D. The force per unit mass acting on a small test mass

23. The Earth is a distance r_S from the Sun. The Moon is a distance r_M from the Earth.

The ratio $\frac{\text{gravitational field strength at the Earth due to the Sun}}{\text{gravitational field strength at the Earth due to the Moon}}$ is proportional to

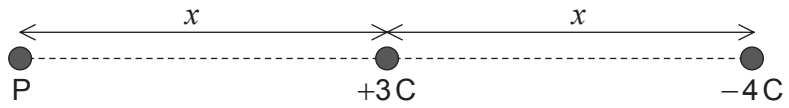
A. $\frac{r_M}{r_S}$.

B. $\frac{r_S}{r_M}$.

C. $\frac{r_S^2}{r_M^2}$.

D. $\frac{r_M^2}{r_S^2}$.

24. A $+3\,\text{C}$ charge and a $-4\,\text{C}$ charge are a distance x apart. P is a distance x from the $+3\,\text{C}$ charge on the straight line joining the charges.



What is the magnitude of the electric field strength at P?

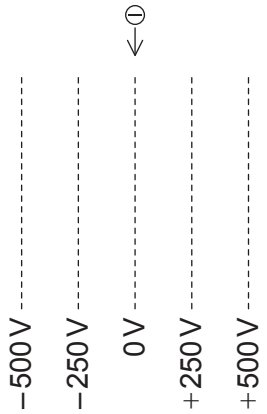
A. $\frac{1}{\pi\varepsilon_0 x^2}$

B. $\frac{1}{2\pi\varepsilon_0 x^2}$

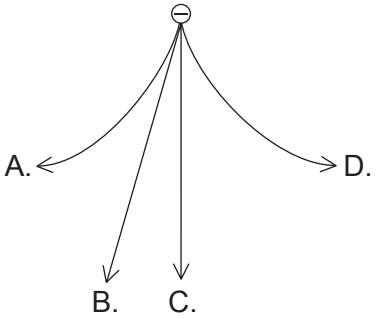
C. $\frac{1}{4\pi\varepsilon_0 x^2}$

D. $\frac{1}{7\pi\varepsilon_0 x^2}$

25. A negatively charged particle falls vertically into a region where there is an electric field. The equipotentials of this field are shown.



What is the path followed by the particle?



26. A simple model of the hydrogen atom suggests that the electron orbits the proton. What is the force that keeps the electron in orbit?

A. Electrostatic

B. Gravitational

C. Strong nuclear

D. Centripetal

27. Bismuth-210 $\left({}^{210}_{83}\text{Bi}\right)$ is a radioactive isotope that decays as follows.

$$^{210}_{83}\text{Bi} \xrightarrow{\beta^-} \text{X} \xrightarrow{\alpha} \text{Y}$$

What are the mass number and proton number of Y?

	Mass number	Proton number
A.	206	86
B.	206	82
C.	210	82
D.	214	83

28. When electromagnetic radiation falls on a photocell, electrons of mass m_e are emitted, provided the frequency of the radiation is greater than f_0. What is the maximum speed of the electron when radiation of frequency f falls on the photocell?

A. $\sqrt{\frac{2hf}{m_e}}$

B. $\sqrt{\frac{2h(f-f_0)}{m_e}}$

C. $\sqrt{\frac{hf}{m_e}}$

D. $\sqrt{\frac{h(f-f_0)}{m_e}}$

29. What was the principal result of the Davisson–Germer experiment?

A. It demonstrated electron diffraction.

B. It confirmed Rutherford's ideas about the nucleus.

C. It demonstrated the photoelectric effect.

D. It confirmed Heisenberg's ideas about uncertainty.

30. A particle has a de Broglie wavelength λ and kinetic energy E. What is the relationship between λ and E?

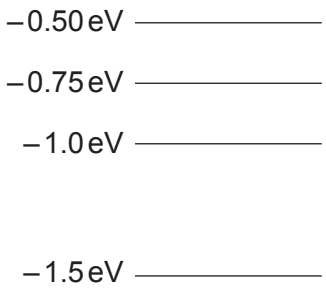
A. $\lambda \propto E^{\frac{1}{2}}$

B. $\lambda \propto E$

C. $\lambda \propto E^{-\frac{1}{2}}$

D. $\lambda \propto E^{-1}$

31. All the energy levels in a simple model of an atom are shown.



The atom is excited so that an electron is promoted to the – 0.50 eV energy level. How many different frequencies will be observed in the emission spectrum?

A. 3

B. 4

C. 5

D. 6

32. A charged particle enters a uniform magnetic field at 90° to the magnetic field lines in a Bainbridge mass spectrometer. What happens to the momentum of the particle and the kinetic energy of the particle as the charged particle moves in the magnetic field?

	Momentum	Kinetic energy
A.	changed	changed
B.	unchanged	changed
C.	changed	unchanged
D.	unchanged	unchanged

33. $^{11}_{6}C$ undergoes β^+ decay. The products of this decay are the β^+ particle, X and Y. What are X and Y?

	X	Y
A.	$^{11}_{5}B$	antineutrino
B.	$^{11}_{5}B$	neutrino
C.	$^{11}_{7}N$	antineutrino
D.	$^{11}_{7}N$	neutrino

34. For fissile material, fuel enrichment is the

A. increase in the ratio of $\frac{\text{uranium-235}}{\text{uranium-238}}$.

B. conversion of uranium-235 to uranium-238.

C. conversion of uranium-238 to plutonium-239.

D. increase in the ratio of $\frac{\text{uranium-238}}{\text{uranium-235}}$.

35. It is suggested that the solar power incident at a point on the Earth's surface depends on

I. daily variations in the Sun's power output
II. the location of the point
III. the cloud cover at the point.

Which suggestion(s) is/are correct?

A. III only

B. I and II only

C. II and III only

D. I, II and III

36. Waves are incident on an oscillating water column (OWC) ocean-wave energy converter with an available power P. What is the available power for this converter when the wave amplitude is halved and the wave speed is doubled?

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

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

C. P

D. $4P$

37. The average surface temperature of Mars is about 200 K. The average surface temperature of Earth is about 300 K. Both can be regarded as black bodies.

What is the ratio $\frac{\text{energy radiated per second per unit area on Mars}}{\text{energy radiated per second per unit area on Earth}}$?

A. 0.7

B. 0.4

C. 0.3

D. 0.2

38. Which of the following can only be used to store analogue information?

A. LP (vinyl record)

B. Cassette tape

C. CD

D. DVD

39. In a CD player, there is light

I. from reflections from lands on the CD
II. from reflections from pits on the CD
III. direct from the laser.

What light is involved in the interference that allows information to be recovered from a CD?

A. II only

B. I and II only

C. I and III only

D. II and III only

40. Analogue audio signals are sampled and digitally stored on a device that can hold 4.8 Mbits of information. The sampling rate is 40 kbits per second. What is the maximum duration of the audio signal that can be stored?

A. 120 ms

B. 833 ms

C. 120 s

D. 833 s