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**Physics**  
**Standard level**  
**Paper 1**

Monday 3 May 2021 (afternoon)

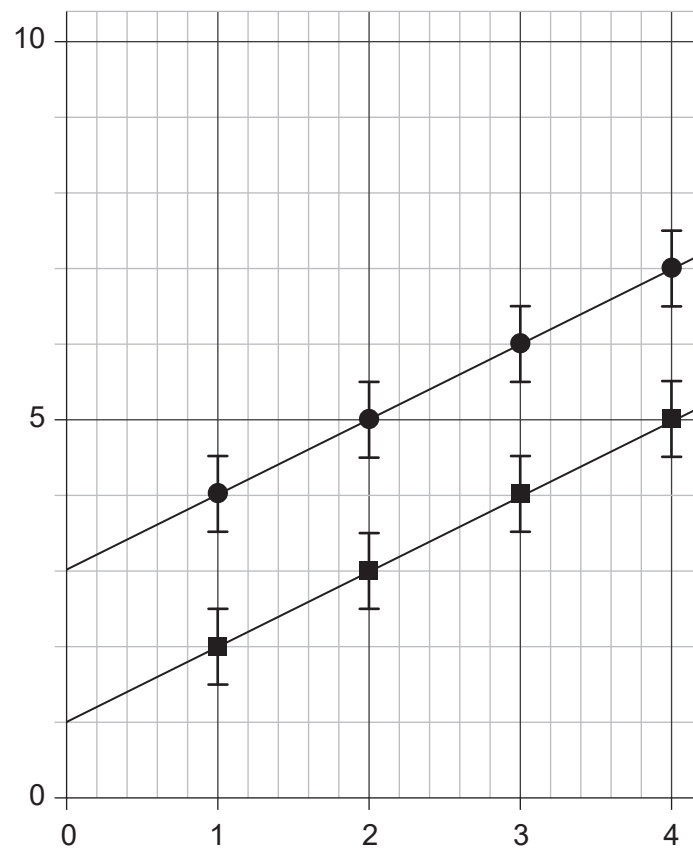
45 minutes

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**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]**.

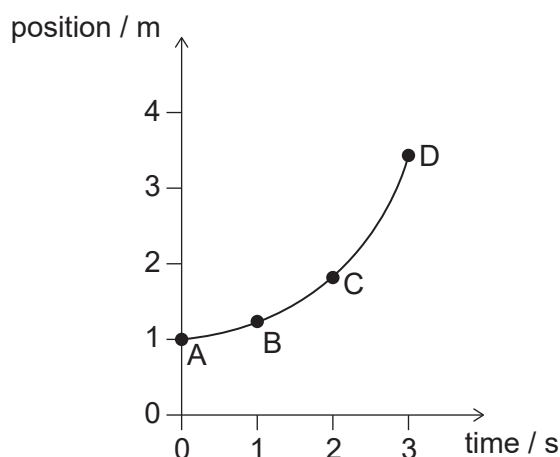
1. Which lists one scalar and two vector quantities?
  - A. Mass, momentum, potential difference
  - B. Mass, power, velocity
  - C. Power, intensity, velocity
  - D. Power, momentum, velocity
  
2. Two sets of data, shown below with circles and squares, are obtained in two experiments. The size of the error bars is the same for all points.



What is correct about the absolute uncertainty and the fractional uncertainty of the y intercept of the two lines of best fit?

|    | Absolute uncertainty | Fractional uncertainty |
|----|----------------------|------------------------|
| A. | larger for squares   | same                   |
| B. | larger for squares   | larger for squares     |
| C. | same                 | same                   |
| D. | same                 | larger for squares     |

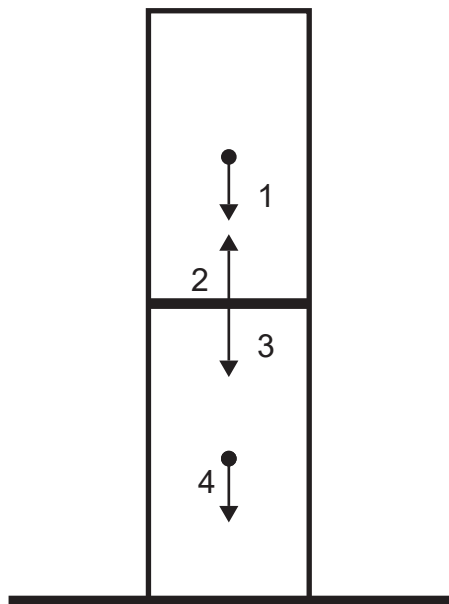
3. A large stone is dropped from a tall building. What is correct about the speed of the stone after 1 s?
- A. It is decreasing at increasing rate.
  - B. It is decreasing at decreasing rate.
  - C. It is increasing at increasing rate.
  - D. It is increasing at decreasing rate.
4. The graph shows how the position of an object varies with time in the interval from 0 to 3 s.



At which point does the instantaneous speed of the object equal its average speed over the interval from 0 to 3 s?

5. A car takes 20 minutes to climb a hill at constant speed. The mass of the car is 1200 kg and the car gains gravitational potential energy at a rate of 6.0 kW. Take the acceleration of gravity to be  $10 \text{ m s}^{-2}$ . What is the height of the hill?
- A. 0.6 m
  - B. 10 m
  - C. 600 m
  - D. 6000 m

6. A ball undergoes an elastic collision with a vertical wall. Which of the following is equal to zero?
- A. The change of the magnitude of linear momentum of the ball
  - B. The magnitude of the change of linear momentum of the ball
  - C. The rate of change of linear momentum of the ball
  - D. The impulse of the force on the ball
7. Two forces act on an object in different directions. The magnitudes of the forces are 18 N and 27 N. The mass of the object is 9.0 kg. What is a possible value for the acceleration of the object?
- A.  $0\text{ ms}^{-2}$
  - B.  $0.5\text{ ms}^{-2}$
  - C.  $2.0\text{ ms}^{-2}$
  - D.  $6.0\text{ ms}^{-2}$
8. Two identical boxes are stored in a warehouse as shown in the diagram. Two forces acting on the top box and two forces acting on the bottom box are shown.

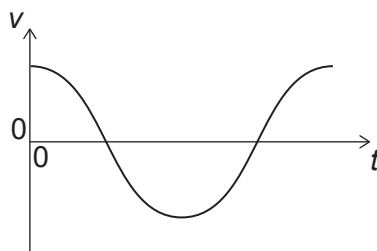


Which is a force pair according to Newton's third law?

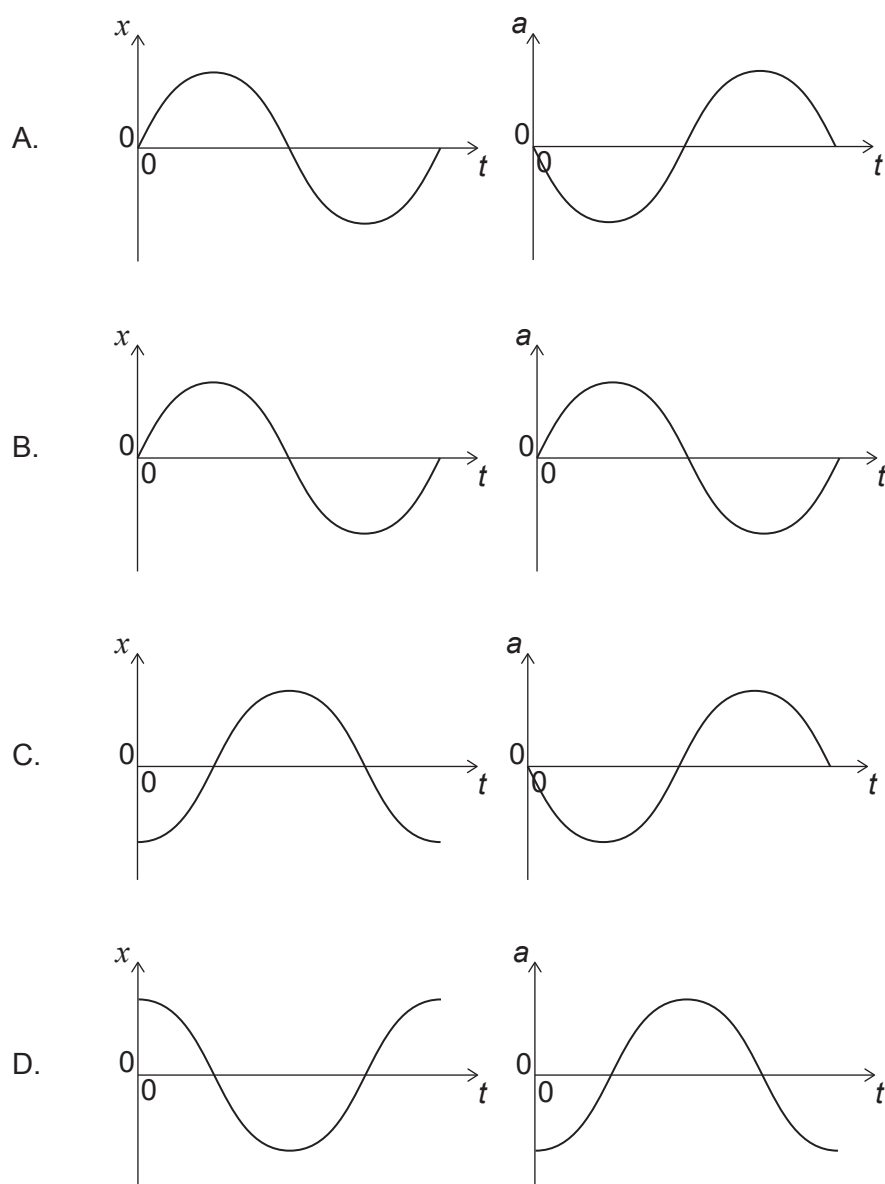
- A. 1 and 2
- B. 3 and 4
- C. 2 and 3
- D. 2 and 4

9. An electron has a linear momentum of  $4.0 \times 10^{-25} \text{ kg m s}^{-1}$ . What is the order of magnitude of the kinetic energy of the electron?
- A.  $10^{-50} \text{ J}$   
 B.  $10^{-34} \text{ J}$   
 C.  $10^{-19} \text{ J}$   
 D.  $10^6 \text{ J}$
10. Which aspect of thermal physics is best explained by the molecular kinetic model?
- A. The equation of state of ideal gases  
 B. The difference between Celsius and Kelvin temperature  
 C. The value of the Avogadro constant  
 D. The existence of gaseous isotopes
11. When 40 kJ of energy is transferred to a quantity of a liquid substance, its temperature increases by 20 K. When 600 kJ of energy is transferred to the same quantity of the liquid at its boiling temperature, it vaporizes completely at constant temperature. What is
- $\frac{\text{specific latent heat of vaporization}}{\text{specific heat capacity of the liquid}}$
- for this substance?
- A.  $15 \text{ K}^{-1}$   
 B. 15 K  
 C.  $300 \text{ K}^{-1}$   
 D. 300 K
12. A quantity of 2.00 mol of an ideal gas is maintained at a temperature of  $127^\circ\text{C}$  in a container of volume  $0.083 \text{ m}^3$ . What is the pressure of the gas?
- A. 8 kPa  
 B. 25 kPa  
 C. 40 kPa  
 D. 80 kPa

13. An object performs simple harmonic motion (shm). The graph shows how the velocity  $v$  of the object varies with time  $t$ .



The displacement of the object is  $x$  and its acceleration is  $a$ . What is the variation of  $x$  with  $t$  and the variation of  $a$  with  $t$ ?



14. A sound wave has a frequency of 1.0 kHz and a wavelength of 0.33 m. What is the distance travelled by the wave in 2.0 ms and the nature of the wave?

|    | Distance travelled in 2.0 ms | Nature of the wave |
|----|------------------------------|--------------------|
| A. | 0.17 m                       | longitudinal       |
| B. | 0.17 m                       | transverse         |
| C. | 0.66 m                       | longitudinal       |
| D. | 0.66 m                       | transverse         |

15. Two identical waves, each with amplitude  $X_0$  and intensity  $I$ , interfere constructively. What are the amplitude and intensity of the resultant wave?

|    | Amplitude of the resultant wave | Intensity of the resultant wave |
|----|---------------------------------|---------------------------------|
| A. | $X_0$                           | $2I$                            |
| B. | $2X_0$                          | $2I$                            |
| C. | $X_0$                           | $4I$                            |
| D. | $2X_0$                          | $4I$                            |

16. Three quantities used to describe a light wave are

- I. frequency
- II. wavelength
- III. speed.

Which quantities increase when the light wave passes from water to air?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III



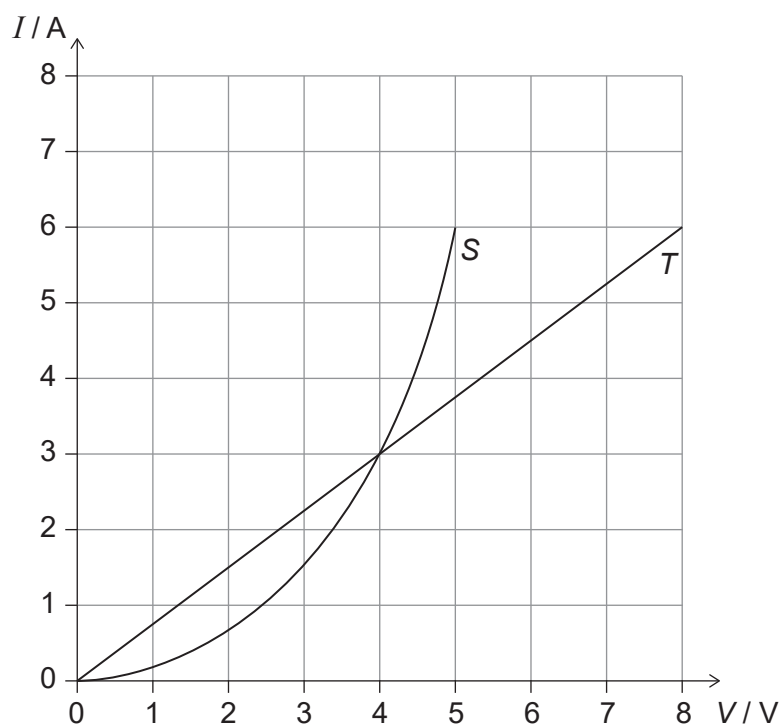
17. A pipe of length  $L$  is closed at one end. Another pipe is open at both ends and has length  $2L$ . What is the lowest common frequency for the standing waves in the pipes?

- A.  $\frac{\text{speed of sound in air}}{8L}$
- B.  $\frac{\text{speed of sound in air}}{4L}$
- C.  $\frac{\text{speed of sound in air}}{2L}$
- D.  $\frac{\text{speed of sound in air}}{L}$

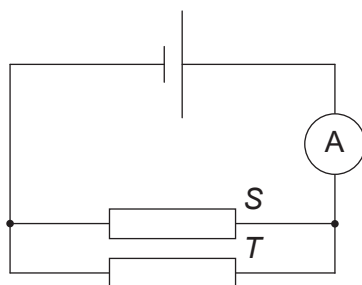
18. Two charges  $Q_1$  and  $Q_2$ , each equal to 2 nC, are separated by a distance 3 m in a vacuum. What is the electric force on  $Q_2$  and the electric field due to  $Q_1$  at the position of  $Q_2$ ?

|    | Electric force on $Q_2$      | Electric field due to $Q_1$ at the position of $Q_2$ |
|----|------------------------------|------------------------------------------------------|
| A. | $4 \times 10^{-9} \text{ N}$ | $2 \text{ N C}^{-1}$                                 |
| B. | $4 \text{ N}$                | $2 \text{ N C}^{-1}$                                 |
| C. | $4 \times 10^{-9} \text{ N}$ | $2 \times 10^{-9} \text{ N C}^{-1}$                  |
| D. | $4 \text{ N}$                | $2 \times 10^{-9} \text{ N C}^{-1}$                  |

19. Two conductors  $S$  and  $T$  have the  $V/I$  characteristic graphs shown below.



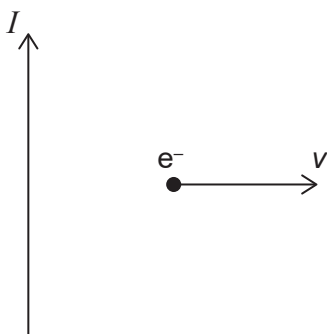
When the conductors are placed in the circuit below, the reading of the ammeter is  $6.0\text{ A}$ .



What is the emf of the cell?

- A.  $4.0\text{ V}$
- B.  $5.0\text{ V}$
- C.  $8.0\text{ V}$
- D.  $13\text{ V}$

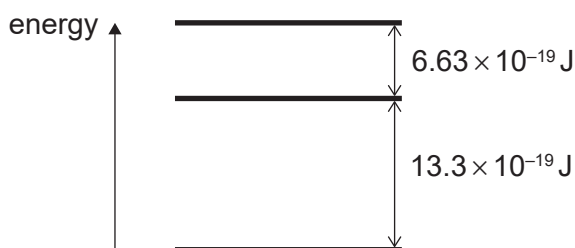
20. For a real cell in a circuit, the terminal potential difference is at its closest to the emf when
- A. the internal resistance is much smaller than the load resistance.
  - B. a large current flows in the circuit.
  - C. the cell is not completely discharged.
  - D. the cell is being recharged.
21. A long straight vertical conductor carries a current  $I$  upwards. An electron moves with horizontal speed  $v$  to the right.



What is the direction of the magnetic force on the electron?

- A. Downwards
  - B. Upwards
  - C. Into the page
  - D. Out of the page
22. A child stands on a horizontal rotating platform that is moving at constant angular speed. The centripetal force on the child is provided by
- A. the gravitational force on the child.
  - B. the friction on the child's feet.
  - C. the tension in the child's muscles.
  - D. the normal reaction of the platform on the child.

23. Which is the definition of gravitational field strength at a point?
- A. The sum of the gravitational fields created by all masses around the point
  - B. The gravitational force per unit mass experienced by a small point mass at that point
  - C.  $G \frac{M}{r^2}$ , where  $M$  is the mass of a planet and  $r$  is the distance from the planet to the point
  - D. The resultant force of gravitational attraction on a mass at that point
24. A simple model of an atom has three energy levels. The differences between adjacent energy levels are shown below.



What are the two smallest frequencies in the emission spectrum of this atom?

- A.  $0.5 \times 10^{15} \text{ Hz}$  and  $1.0 \times 10^{15} \text{ Hz}$
  - B.  $0.5 \times 10^{15} \text{ Hz}$  and  $1.5 \times 10^{15} \text{ Hz}$
  - C.  $1.0 \times 10^{15} \text{ Hz}$  and  $2.0 \times 10^{15} \text{ Hz}$
  - D.  $1.0 \times 10^{15} \text{ Hz}$  and  $3.0 \times 10^{15} \text{ Hz}$
25. What is the relation between the value of the unified atomic mass unit in grams and the value of Avogadro's constant in  $\text{mol}^{-1}$ ?
- A. Their ratio is 1.
  - B. Their product is 1.
  - C. Their sum is 1.
  - D. Their difference is 0.

26. Three particles are produced when the nuclide  $^{23}_{12}\text{Mg}$  undergoes beta-plus ( $\beta^+$ ) decay. What are two of these particles?

- A.  $^{23}_{11}\text{Na}$  and  $^0_0\nu_e$
- B.  $^0_{-1}e$  and  $^0_0\nu_e$
- C.  $^{23}_{11}\text{Na}$  and  $^0_0\bar{\nu}_e$
- D.  $^0_1e$  and  $^0_0\bar{\nu}_e$

27. A particle reaction is

$$p + e^- + \bar{\nu}_\mu \rightarrow n + \mu^+ + \nu_e.$$

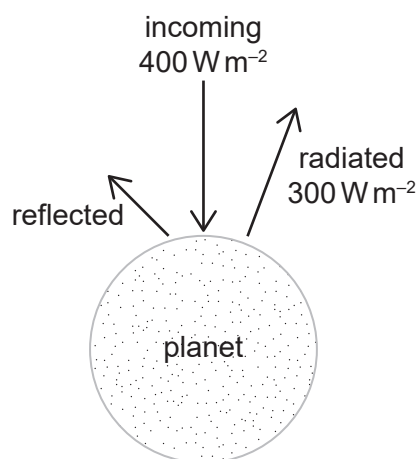
Which conservation law is violated by the reaction?

- A. Baryon number
  - B. Charge
  - C. Lepton number
  - D. Momentum
28. Which change produces the largest percentage increase in the maximum theoretical power output of a wind turbine?
- A. Doubling the area of the blades
  - B. Doubling the density of the fluid
  - C. Doubling the radius of the blades
  - D. Doubling the speed of the fluid

29. A black body at temperature  $T$  emits radiation with peak wavelength  $\lambda_p$  and power  $P$ . What is the temperature of the black body and the power emitted for a peak wavelength of  $\frac{\lambda_p}{2}$ ?

|    | Temperature of the black body | Power emitted by the black body |
|----|-------------------------------|---------------------------------|
| A. | $\frac{T}{2}$                 | $\frac{P}{16}$                  |
| B. | $\frac{T}{2}$                 | $\frac{P}{4}$                   |
| C. | $2T$                          | $4P$                            |
| D. | $2T$                          | $16P$                           |

30. In a simple climate model for a planet, the incoming intensity is  $400 \text{ W m}^{-2}$  and the radiated intensity is  $300 \text{ W m}^{-2}$ .



The temperature of the planet is constant. What are the reflected intensity from the planet and the albedo of the planet?

|    | Reflected intensity from the planet | Albedo of the planet |
|----|-------------------------------------|----------------------|
| A. | $100 \text{ W m}^{-2}$              | 0.25                 |
| B. | $100 \text{ W m}^{-2}$              | 0.75                 |
| C. | $300 \text{ W m}^{-2}$              | 0.25                 |
| D. | $300 \text{ W m}^{-2}$              | 0.75                 |

#### References: