Secondary School Mathematics & Science Competition

Physics

Date: 1st May, 2013
Time allowed: 1 hour 15 minutes

1. Write your Name (both in English and Chinese), Name of School, Form, Date, Sex, Language, Subject and Candidate Number in the spaces provided on the "MC Answer Sheet" and the Part B "Fill In The Blanks Answer Sheet".
2. When told to open this question paper, you should check that all the questions are there. Look for the words '**END OF PAPER**' after the last question.
3. Answer **ALL** questions. You are advised to use an **HB** pencil to mark your answers on the MC Answer Sheet.
4. You should mark only **ONE** answer for each question in Part A. If you mark more than one answer, you will receive **NO MARKS** for that question.
5. **NO MARKS** will be deducted for wrong answers in Part A and Part B.
6. The diagrams in the paper are not necessarily drawn to scale.

PART A

Choose the best answer for each question.

1. Which of the following units is the same as the unit 'newton'?

   A. kg m s^{-1}
   B. kg m s^{-2}
   C. kg m^2 s^{-1}
   D. kg m^2 s^{-2}

2. When two objects with different temperatures are put together, and assuming no heat exchange with the surrounding, which of the following statement(s) is/are correct?
   (1) After a long time, the temperatures of the two objects will be equal.
   (2) The energy decreased in one object is equal to the energy increased in the other object.
   (3) The temperature decreased in one object is equal to the temperature increased in the other object.

   A. (1) and (2) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

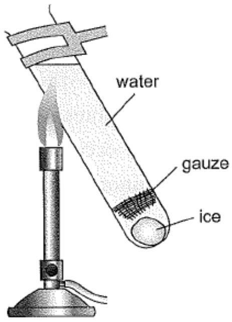
3. Four samples *A*, *B*, *C* and *D* are heated by four identical heaters for 10 seconds. Which sample has the highest specific heat capacity?

	Sample	Mass	Temperature rise
A.	*A*	*m*	*T*
B.	*B*	*2m*	*T*
C.	*C*	*2m*	*2T*
D.	*D*	*4m*	$\frac{T}{2}$

4. How many moles of helium gas would produce a pressure of 800 kPa in a 5.6×10^{-3} m^3 cylinder at a temperature of 20°C?

   A. 0.54 mol
   B. 1.84 mol
   C. 17.74 mol
   D. 30.34 mol

5. A piece of ice is trapped at the bottom of a test tube by a gauze. The test tube is filled with water. A flame then heats the water at the top of the test tube, as shown in the figure. Determine which of the following situations will be observed.

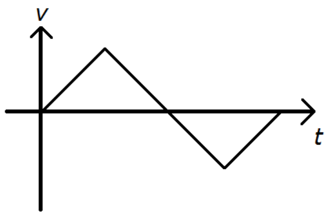


A. The water at the top begins to boil and the ice is completely melted.
B. The water at the top begins to boil but the ice does not completely melt.
C. The water at the bottom begins to boil and the ice is completely melted.
D. The water at the bottom begins to boil but the ice does not completely melt.

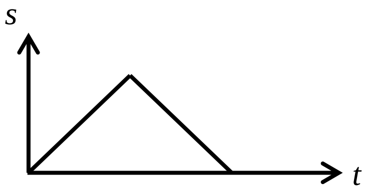
6. A satellite moving round the Moon in a circular orbit of radius R has a period T. What would the period be if the orbit radius is changed to $R/4$?

A. $T/8$
B. $T/4$
C. $T/2$
D. T

7. The velocity *v* of a particle varies with time *t* as shown in the figure. Which of the following graphs best represents the variation of the displacement *s* of the particle with respect to time *t*?

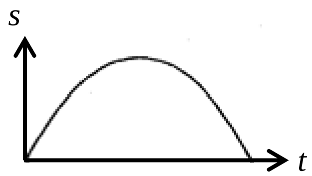


A.

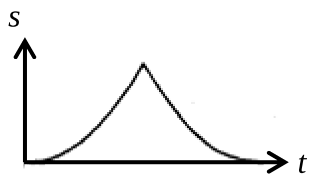


B.

C.



D.



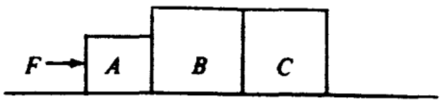
8. A person weighing 100 N stands on a bathroom scale in a lift. If the scale shows a reading of 110 N, describe the motion of the lift.

   A. Moving downwards and decelerating.
   B. Moving downwards with a constant velocity.
   C. Moving upwards and decelerating.
   D. Moving upwards with a constant velocity.

9. A string 0.5 m long is used to whirl a 1 kg stone in a vertical circle at a uniform speed of 5 m s^{-1}. Find the largest tension in the string during its motion.

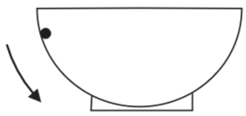
A. 40.2 N
B. 49.1 N
C. 59.8 N
D. 60.2 N

10. Three blocks *A*, *B* and *C* of masses *m*, 2*m* and 3*m* respectively are placed on a smooth horizontal ground as shown in the figure below. A constant horizontal *F* force is applied to block *A* so that the three blocks move with the same acceleration towards the right. What is the resultant force acting on block *C*?



A. *F*/6
B. *F*/3
C. *F*/2
D. *F*

11. A small object of mass 0.05 kg is released from rest at the rim of a heavy, smooth semi-spherical bowl of radius 10 cm. Find the force acting on the object by the bowl when it passes the bottom of the bowl.



A. 0.491 N
B. 0.981 N
C. 1.47 N
D. 1.96 N

12. A body initially at rest disintegrates explosively into two masses m_1 and m_2 which move apart with speeds v_1 and v_2 respectively. The ratio $\frac{v_1}{v_2}$ is equal to

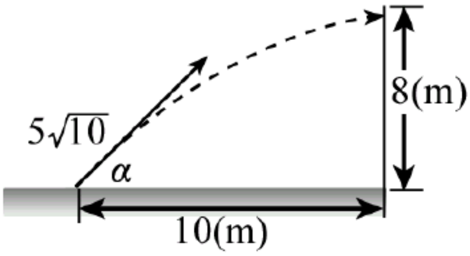
A. $\frac{m_2}{m_1}$.

B. $\frac{m_1}{m_2}$.

C. $\sqrt{\frac{m_2}{m_1}}$.

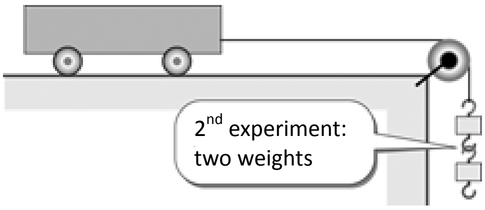
D. $\sqrt{\frac{m_1}{m_2}}$.

13. A particle projects with an initial velocity of $5\sqrt{10}$ m s^{-1}, at an angle α as measured from the horizontal direction. If the particle hits a vertical wall 10 m away at 8 m above the ground, find α.

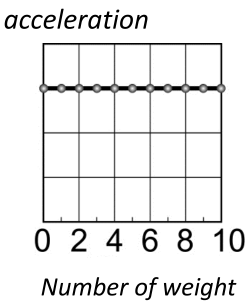


A. 30°
B. 34°
C. 43°
D. 54°

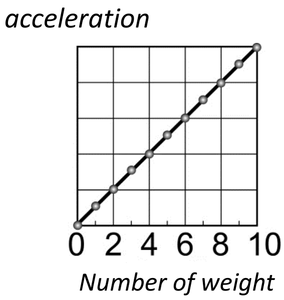
14. A trolley as shown below is hanging weight(s) by a light thread over a smooth pulley. Weights of mass 50 g are added consecutively and the corresponding accelerations of the trolley are recorded. If the mass of the trolley is 100 g, which of the following graphs best represent the relations between the acceleration and the number of weights added?



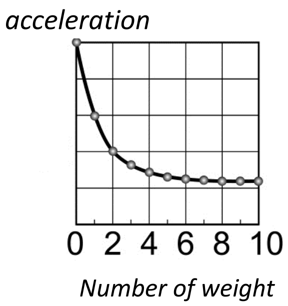
A.



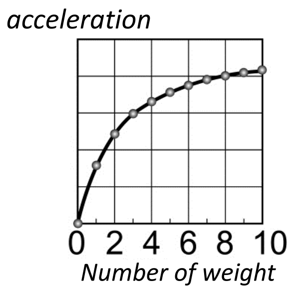
B.



C.



D.



15. Two balls are released from the same height at the same instance, one ball is released without any horizontal velocity, and the other ball is given a horizontal initial velocity. Which of the following statement(s) is/are correct?

(1) They have the same velocity when they reach the ground.
(2) They reach the ground at the same time.
(3) The have the same acceleration throughout the journey.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

16. Which of the followings are the differences between ultrasonic waves and microwaves?
    (1) Microwaves are electromagnetic waves but ultrasonic waves are mechanical waves.
    (2) Microwaves can travel through vacuum but ultrasonic waves cannot.
    (3) Microwaves in air are transverse waves but ultrasonic waves in air are longitudinal waves.

    A. (1) and (2) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

17. It is difficult to observe diffraction of light in daily life. Which of the following is/are the reason(s)?
    (1) The wavelength of visible light is very short.
    (2) The light rays that we see in daily life have various wavelengths.
    (3) The speed of light is very high.

    A. (1) only
    B. (1) and (3) only
    C. (2) and (3) only
    D. (1), (2) and (3)

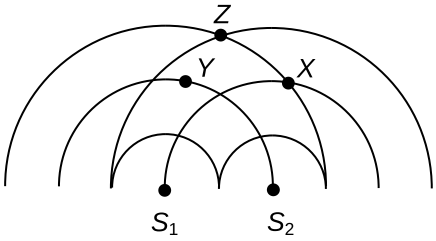
18. A boy sees lightning at the sky and hears the sound of thunder 3 s later. If the speed of sound in the air is 340 m s^{-1}, how far away is he from the thunderstorm?

    A. 510 m
    B. 1020 m
    C. 2040 m
    D. 2550 m

19. A series of ripples travel from a shallow region to a deep region of a lake. The values of its wavelength and frequency in the shallow region are λ and f respectively, and the corresponding values in the deep region are λ' and f' respectively. Which of the following relations is/are correct?
    (1) $\lambda < \lambda'$
    (2) $f\lambda < f'\lambda'$
    (3) $f < f'$

    A. (1) only
    B. (1) and (2) only
    C. (2) and (3) only
    D. (1), (2) and (3)

20. Dippers S_1 and S_2 produce circular wavefronts in a ripple tank. Which of the following statement(s) is/are correct?



(1) Constructive interferences occur at X, Y and Z.
(2) The amplitude of the wave at Y is always zero.
(3) More nodal and antinodal lines can be observed when the frequency of the dippers increases.

A. (1) only
B. (3) only
C. (2) and (3) only
D. (1), (2) and (3)

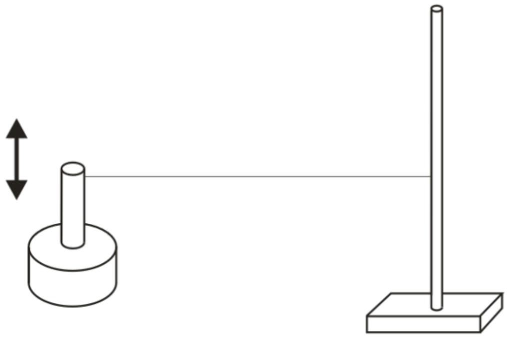
21. A Young's double-slit experiment is performed with the whole set-up immersed in a liquid of refractive index n. If s' and s are the fringe separations in the liquid and in air respectively, what is the ratio $\frac{s'}{s}$?

A. n
B. $\frac{1}{n}$
C. $\frac{n-1}{n}$
D. $\frac{n}{n-1}$

22. A plane transmission grating ruled with 5000 lines per cm is illuminated normally by a white light. If the wavelengths for yellow light and violet light are 0.6 μm and 0.4 μm respectively, which of the following statements is **false**?

A. The central image is white.
B. The violet end of the first-order spectrum is closer to the central image than the yellow end of the first-order spectrum.
C. The second-order bright fringe of yellow light coincides with the third order bright fringe of violet light.
D. There is no fourth-order bright fringe for violet light.

23. An elastic string stretched to 1 m long is fixed at one end to a vibrator and the other to a stand as shown in the figure.



Stationary wave patterns are produced when the vibrator shakes at 12 Hz and 16 Hz. No pattern is produced at frequencies in between these two. The speed of wave along the string is

A. 4 m s^{-1}
B. 8 m s^{-1}
C. 16 m s^{-1}
D. 24 m s^{-1}

24. In the following diagram, intervals *AB*, *BC*, *CD*, *DE* and *EF* are of equal length. An object is placed at *O*. When a lens is put in front of the object, an image of the object is formed at *I*.

Which of the following show(s) the possible position(s), type(s) and focal length(s) of the lens?

	Position	**Type**	**Focal length**
(1)	*C*	convex lens	about 1 interval
(2)	*F*	concave lens	about 2 intervals
(3)	*A*	convex lens	about 2 intervals

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

25. A uniform wire is clamped at both ends which are 0.4 m apart. The tension in the wire is 65 N and the area of its cross-section is $3.0 \times 10^{-7}\ \mathrm{m}^2$. When the wire is plucked to produce transverse vibrations, the frequency of the fundamental note obtained is 160 Hz. The density of the wire is

A. 4400 kg m^{-3}
B. 8800 kg m^{-3}
C. 13200 kg m^{-3}
D. 17600 kg m^{-3}

26. In Young's double-slit experiment, which of the following combinations of monochromatic light, the slit-separation and the slit-to-screen distance would produce the widest fringe separation on the screen?

	Monochromatic light	Slit-separation	Slit-to-screen distance
A.	red light	2 mm	4 m
B.	red light	4 mm	2 m
C.	green light	2 mm	4 m
D.	green light	4 mm	2 m

27. *P* and *Q* are two point charges of the same magnitude but opposite signs. How many points are there in the system such that the electric field strength is zero?

A. 0
B. 1
C. 2
D. Unknown

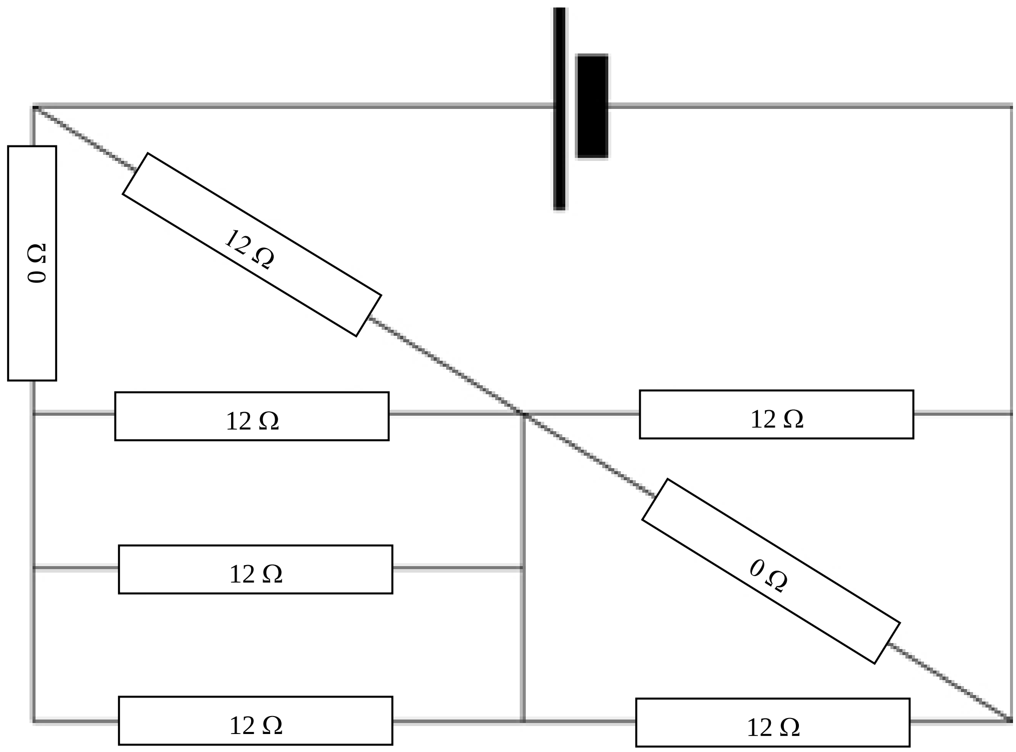
28. *P*, *Q* and *R* are three identical small metal spheres. *P* and *Q* are fixed at a certain separation in vacuum and they carry charges of the same magnitude. The attractive force between them is $2F$. Sphere *R* is initially uncharged. It first touches *P* and then it touches *Q*. What is the electrostatic force between *P* and *Q* after *R* is taken away?

A. $F/4$
B. $F/8$
C. $3F/4$
D. $3F/8$

29. Watt per voltage is a unit of

A. electrical energy
B. electrical power
C. potential difference
D. electric current

30. Find the equivalent resistance of the below circuit.

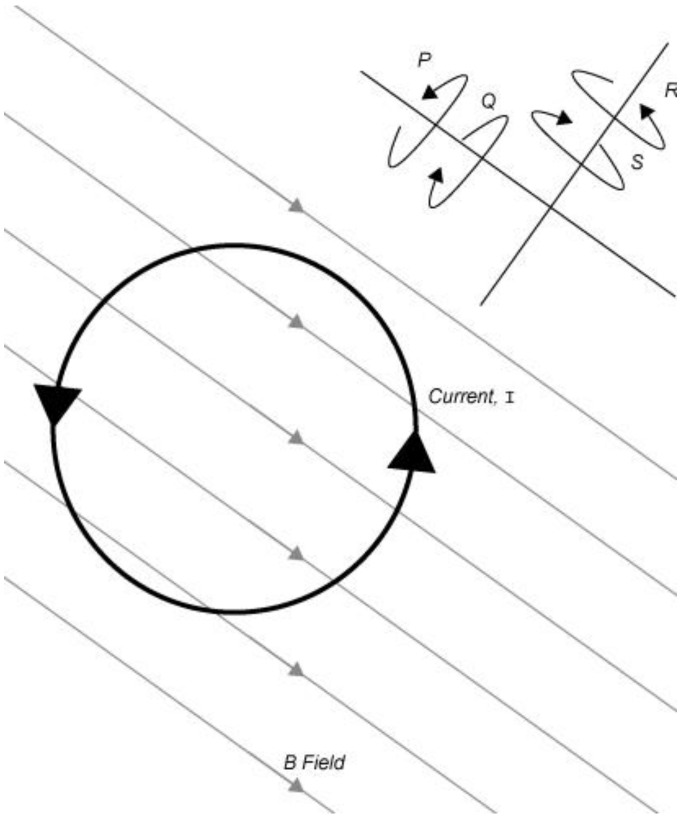


A. 3 Ω
B. 8 Ω
C. 12 Ω
D. 16 Ω

31. A 1 V battery is connected in series with a resistor. The voltage across the resistor is 1 V. Which of the following statements is correct?

A. When 0.5 C of charge passes through the battery, 0.5 J of the electric potential energy is converted into other forms of energy.
B. When 0.5 C of charge passes through the battery, 2 J of the electric potential energy is converted into other forms of energy.
C. When 0.5 C of charge passes through the resistor, 0.5 J of the electric potential energy is converted into other forms of energy.
D. When 0.5 C of charge passes through the resistor, 2 J of the electric potential energy is converted into other forms of energy.

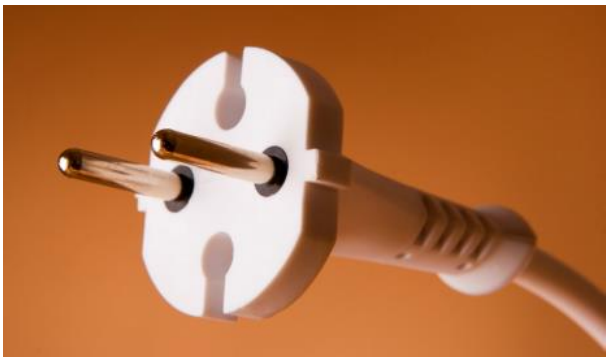
32.



A circular loop carrying a current *I* is placed in a uniform magnetic field *B* in the plane as shown. If the loop is free to move, the magnetic forces will cause it to

A. rotate about the *y*-axis as indicated by *P*.
B. rotate about the *y*-axis as indicated by *Q*.
C. rotate about the *x*-axis as indicated by *R.*
D. rotate about the *x*-axis as indicated by *S*.

33. The following figure shows a two-pin plug connecting an old-fashioned electric cooker to the mains supply.



Which of the following statement(s) is/are correct?

(1) There is no neutral wire in the plug.

(2) If the live wire in the cooker touches the metal case, people touching the cooker is likely to have an electric shock.

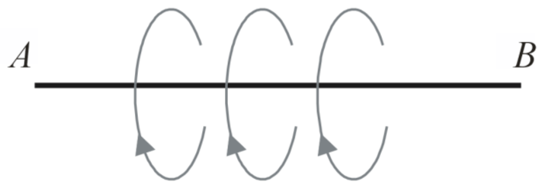
(3) The operating current of a cooker using a two-pin plug is smaller than that using a three-pin plug.

A. (2) only
B. (3) only
C. (2) and (3) only
D. (1), (2) and (3)

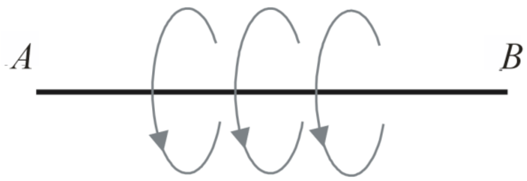
34. The following figure shows a current flowing along a wire, from *A* to *B*

Which of the following figures best represents the magnetic field produced?

A.

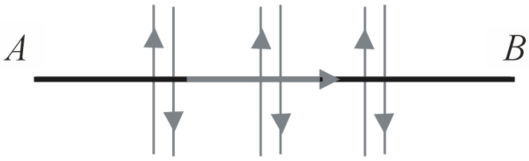


B.

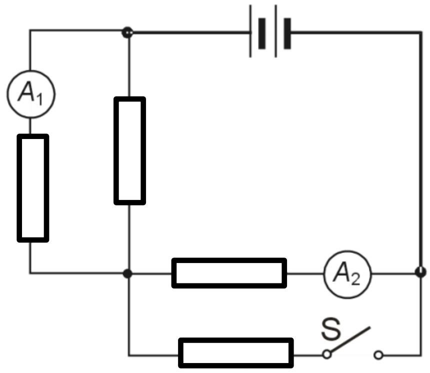


C.

D.

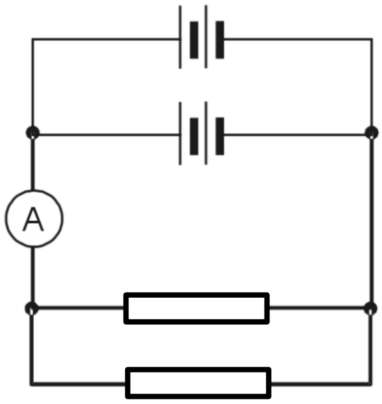


35. All resistors in the following circuit are identical. When the switch of the circuit is closed, how do the readings of ammeters A_1 and A_2 change?



	Reading of A_1	**Reading of A_2**
A	Increases	Decreases
B	Decreases	Increases
C	Increases	Increases
D	Decreases	Decreases

36. In the following figure, each resistor has a resistance of R, and each cell has an internal resistance of r and an e.m.f. of ε.



What is the reading of the ammeter?

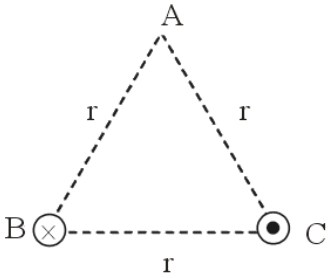
A. $\dfrac{2\varepsilon}{2r+R}$

B. $\dfrac{2\varepsilon}{4r+2R}$

C. $\dfrac{4\varepsilon}{r+R}$

D. $\dfrac{4\varepsilon}{4r+R}$

37. As shown below, *ABC* are the vertices on an equilateral triangle of side length *r*. Two long straight parallel wires, running along the direction perpendicular to the plane of the paper and each carrying a current *I*, are placed at points *B* and *C* respectively.



What is the magnetic field at A?

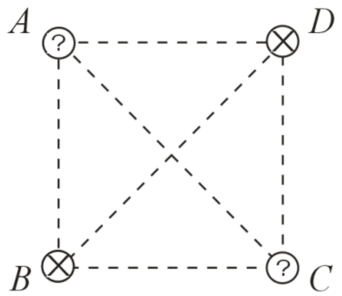
A. $\frac{\mu_o I}{2\pi r}$ (to the left)

B. $\frac{\sqrt{3}\mu_0 I}{2\pi r}$ (to the left)

C. $\frac{\mu_o I}{2\pi r}$ (downwards)

D. $\frac{\sqrt{3}\mu_0 I}{2\pi r}$ (downwards)

38. Four long parallel wires *A*, *B*, *C* and *D* carrying equal current and running in the direction perpendicular to the plane of the paper, are placed at the corners of a square. The currents in *B* and *D* flow into the paper.



If the magnetic field in the middle of the square points towards *D*, what are the directions of current in *A* and *C*?

	Wire *A*	**Wire *C***
A.	Into the paper	Into the paper
B.	Into the paper	Out of the paper
C.	Out of the paper	Into the paper
D.	Out of the paper	Out of the paper

39. Which of the following shows the ranges of penetration different types of nuclear radiation in air in descending order?

A. γ, β, α
B. β, γ, α
C. β, α, γ
D. α, β, γ

40. Which of the following statements about an atom of $^{228}_{89}X$ is/are correct?

(1) It contains 89 protons.
(2) It contains 228 neutrons.
(3) Its mass is about 228 times that of a proton.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (1), (2) and (3) only

41. Which of the following are the applications of radioisotopes?

(1) Radiotherapy
(2) Photocopying
(3) Carbon-14 dating

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

42. The activity of a sample of radioactive isotopes decreases to 1/10 of its initial value in 5 s. How much more time would be required for the activity to decrease to 1/100 of its initial value?

A. 5 s
B. 10 s
C. 50 s
D. 100 s

43. A stationary radioactive nucleus of mass N units emits an α particle of mass 4 units, leaving a residual nucleus of mass $(N-4)$ units. The ratio of the kinetic energy of the α particles to the kinetic energy of the residual nucleus is

A. $\dfrac{N-4}{4}$
B. $\dfrac{N^2}{(N-4)^2}$
C. $\dfrac{(N-4)^2}{N^2}$
D. $\dfrac{(N-4)^2}{4^2}$

PART B

1. When somebody suffers from a fever, the elderly Chinese often suggest covering his body with thick quilts will make one feel much better after sweating.
   (a) A person sweats 2 kg of water in 1 hour. How much energy is required to evaporate this amount of sweat?
   Take the specific latent heat of vaporization of sweat = 2.26×10^6 J kg^{-1}. (2 marks)
   (b) If this amount of energy is not removed from the body, by how much would the body temperature of a person of mass 60 kg rise? The average specific heat capacity of the human body is 3500 J kg^{-1} °C^{-1}. (2 marks)

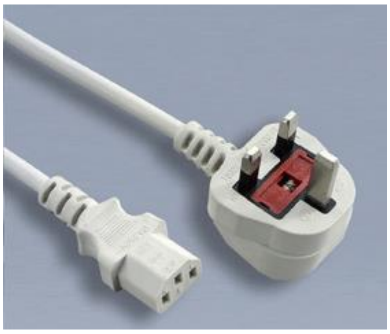
2. A student holds a uniform ruler at one end in two different ways, as shown in Figure 1.1 and Figure 1.2 below


Fig 1.1


Fig 1.2

(i) On Fig. 1.1, draw and label an arrow to represent the weight *W* to the ruler and an arrow to represent the force *F* provided by the student's hand. What is the relationship between the magnitudes of *F* and *W*? (2 marks)
(ii) On Fig. 1.2, the rule is supported by the first finger and is held in the horizontal position by the thumb. On Fig 1.2, draw and label all forces acting on the ruler. List these forces in order of increasing magnitude. (2 marks)

3. The following diagram shows a computer power cord.



   (a) Which end of the power cord should be connected to computer? (1 mark)
   (b) Explain briefly why it is not recommended to design a power cord with plugs at both ends. (3 marks)

End of Paper