NATIONAL PHYSICS COMPETITION 2007

Organised by

Malaysian Institute of Physics

With the cooperation of

Malaysian Ministry of Education

PHYSICS

SECONDARY LEVEL

Two hours and 30 minutes

Instructions to participants

1. This test consists of 70 questions.
2. Answer **all** questions.
3. For each question, four or five suggested answers are given: you are required to choose the most suitable answer and blacken only **one** space on the answer sheet.
4. If you wish to change your answer, erase the blackened mark that you have made. Then blacken the space for the new answer.
5. The diagrams in the questions provided are not drawn to scale unless stated.
6. You may use a non-programmable scientific calculator.
7. Marks will not be deducted for incorrect answers.
8. Total marks for this paper is 70.

Important

For this question paper, assume that

g = 10 m s^{-2} 1 u = 1.66 x 10^{-27} kg

N_A = 6.02 x 10^{23} per mol c = 3.00 x 10^8 m s^{-1}

This question paper consists of 11 printed pages

1 According to Poiseuille's Law, the mass of liquid flowing in a uniform tube per unit time, Ḟ, is given by the formula : $\dot{F} = \frac{(p_2 - p_1)\pi r^4}{8\eta\ell}$ where $(p_2 - p_1)$ is the difference in pressure, r and ℓ are radius and length of the tube respectively. What is the S.I. unit for the coefficient of viscosity of the fluid, η?

A N m kg^{-1} s **B** N m^{-1} kg s **C** N m kg s **D** N kg^{-1} m **E** N m^2 kg^{-1} s^{-1}

2 An ant of mass 0.0000067 kg sits on a flower of mass 0.01234 kg. Find the total mass supported by the stem of the flower to appropriate significant figures.

A 0.0123467 kg **B** 0.012347 kg **C** 0.01235 kg **D** 0.01234 kg **E** 0.012346 kg

3 Figure 1 shows the speed-time graph of the motion of a car. What is the ratio of the distance travelled by the car during the last two seconds to the total distance travelled in the seven seconds?

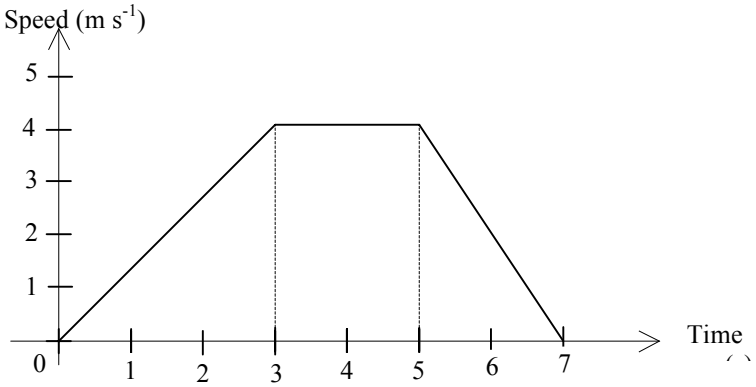


Figure 1

A $\frac{1}{9}$ **B** $\frac{2}{9}$ **C** $\frac{1}{3}$ **D** $\frac{4}{9}$ **E** $\frac{2}{7}$

4 A train covers half the distance of its journey with a speed 20 m s^{-1} and the other half with a speed of 40 m s^{-1}. The average speed of the train during the whole journey is

A 25 m s^{-1} **B** 27 m s^{-1} **C** 30 m s^{-1} **D** 32 m s^{-1} **E** 35 m s^{-1}

5 A body, starting from rest and moving with a constant acceleration, covers a distance x_1 in the 4th second and x_2 in the 6th second. The ratio of $\frac{x_1}{x_2}$ is

A $\frac{2}{3}$ **B** $\frac{4}{9}$ **C** $\frac{6}{11}$ **D** $\frac{7}{11}$ **E** $\frac{9}{13}$

6 A simple pendulum is hanging from the ceiling of a compartment of a train. It is observed that the string is inclined towards the rear of the train. It follows that the train is

A at rest **B** accelerating **C** decelerating **D** in uniform motion

7 A 810-kg car accelerates from rest to 27 m s^{-1} in a distance of 120 m. What is the magnitude of the average net force acting on the car?

A 740 N **B** 91 N **C** 2500 N **D** 7900 N **E** 21870 N

8

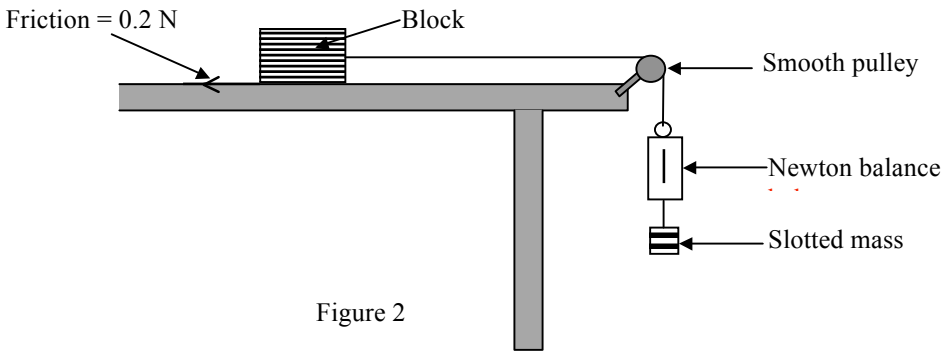


Figure 2

Figure 2 shows a 100 g slotted mass hanging from a Newton balance of mass 20 g, connected to a 380 g block through a smooth pulley. When the 100 g slotted mass is released, the system shown above moves with acceleration. What is the reading of the Newton balance while the system is moving as said?

A 0.8 N **B** 1.0 N **C** 1.2 N **D** 3.8 N **E** 5.0 N

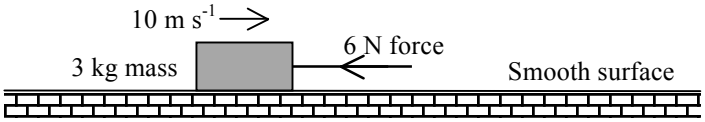
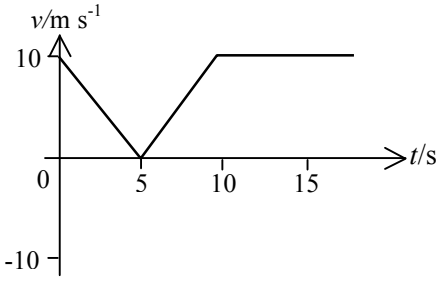


Figure 3

9 A 3 kg mass is moving to the right with initial velocity 10 m s^{-1} on a smooth surface as shown in Figure 3. Then a 6 N force acts on it to the left for a period of 10 s. Which of the following velocity-time graphs describes the motion of the mass correctly?

A


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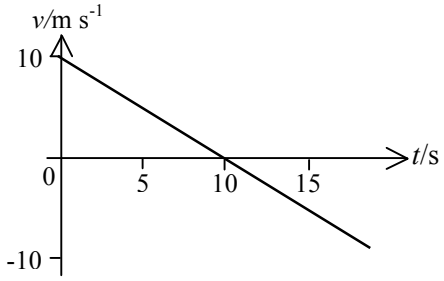
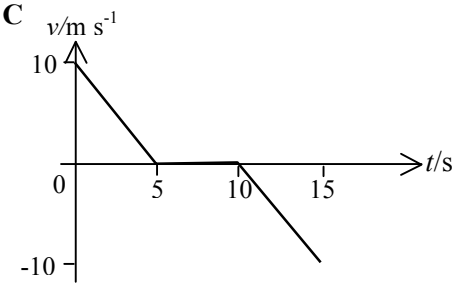
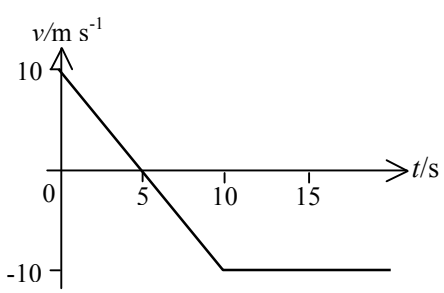


C


D


10 Figure 4 shows velocity, v as a function of time, t for a particle moving in a straight line. Which of the following represents the corresponding displacement-time graph?

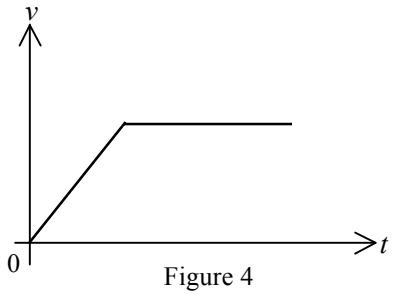
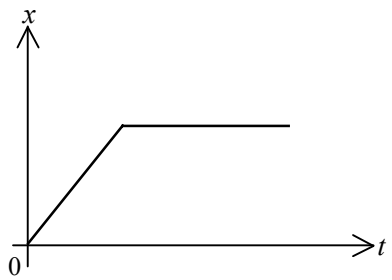


Figure 4

A


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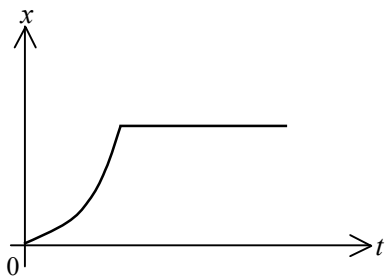

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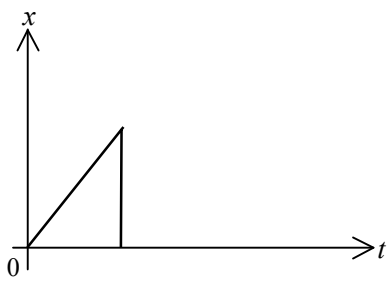

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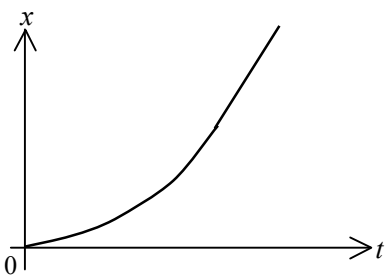


11 A string that can sustain a maximum tension of 40 N is fastened to a mass of 2.0 kg lying on a smooth table. The largest acceleration in m s^{-2} that can be imparted to the mass by pulling it with the string without breaking the string will be

A 19.6 **B** 20 **C** 40 **D** 80 **E** 160

12 A runner takes 45 seconds to run around a circular track of radius 64 m. What is the average velocity of the runner?

A 0 m s^{-1} **B** 0.70 m s^{-1} **C** 2.8 m s^{-1} **D** 8.9 m s^{-1} **E** 17.9 m s^{-1}

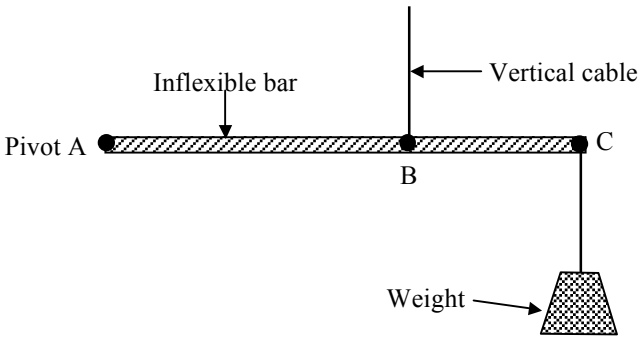


Figure 5

13 An inflexible bar is fixed to a pivot at point A, as shown in Figure 5. A vertical cable, attached to the bar at point B, holds the bar in a horizontal position. A weight is suspended from the bar at point C. The distance from A to B is twice the distance from B to C. If the tension in the cable is 150 N, what is the mass of the weight?

A 3 kg **B** 10 kg **C** 20 kg **D** 30 kg **E** 45 kg

14 A train of length 150 m is going towards the north at a speed of 10 m s^{-1}. A bird flies at 5 m s^{-1} towards the south parallel to the railway track. The time taken for the bird to cross the train is equal to

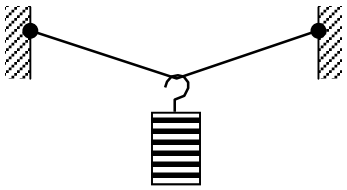
A 8 s **B** 10 s **C** 12 **D** 15 **E** 30 s

15 Two particles of masses m and 4m have linear kinetic energies in the ratio 2:1. What is the ratio of their linear momenta?

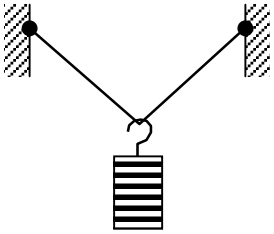
A $\frac{1}{16}$ **B** $\frac{1}{8}$ **C** $\frac{1}{4}$ **D** $\frac{1}{2}$ **E** $\frac{1}{\sqrt{2}}$

16 A block of weight W is suspended on a smooth string of fixed length. The ends of the string are held at various positions as shown in the diagrams below. In which case, is the magnitude of the tension along the string the largest?

A

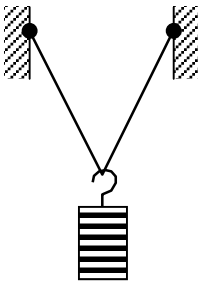


B



C

D



E It will be the same in all four cases, since the string must support the entire weight of the block.

17 A steel rod of mass m and length l is pivoted at one end. It is inclined upwards from the pivot at an angle θ to the horizontal. Taking the pivot to be the reference level, the potential energy of the steel rod will be

A $\frac{1}{2}mgl\cos\theta$ **B** $\frac{1}{2}mgl\sin\theta$ **C** $\frac{1}{2}mgl(1-\cos\theta)$ **D** $mgl\sin\theta$ **E** $\frac{1}{2}$mg$l$ (1–sin θ)

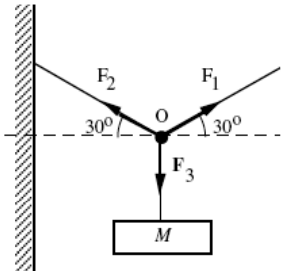


Figure 6

18 A block of mass M is hung by ropes as shown in Figure 6. The system is in equilibrium. The point O represents the knot, the junction of the three ropes. Which of the following statements is true concerning the magnitudes of the three forces in equilibrium?

A $F_1 = F_2 = F_3$ **B** $F_2 = 2F_3$ **C** $F_2 < F_3$ **D** $F_3 = F_1 + F_2$ **E** $F_1 > F_3$

19

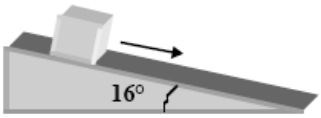


Figure 7

An ice cube with density 917 kg m^{-3}, is sliding down a frictionless inclined plane as shown in Figure 7. The edges of the cube each have a length of 0.75 m. What pressure does the cube exert on the inclined plane?

A 1900 Pa **B** 2700 Pa **C** 5200 Pa **D** 6600 Pa **E** 6900 Pa

20 Within a certain type of star called a neutron star, the material at the centre has a mass density of 1.0×10^{18} kg m^{-3}. If a small sphere of this material of radius 1.0×10^{-5} m were somehow transported to the surface of the earth, what would be the weight of this sphere?

A 1000 N **B** 4200 N **C** 4.2×10^4 N **D** 7.0×10^4 N **E** 3.1×10^9 N

21 A spherical balloon with radius 12. 0 m is filled with helium gas. The fabric of the balloon and its gondola weigh 1930 N. What is the maximum load that can be carried by the balloon so as to be suspended stationary in still air?

[density of air is 1.25 kg m^{-3} and density of helium is 0.16 kg m^{-3}]

A 966 kg **B** 7700 kg **C** 7890 kg **D** 8090 kg **E** 9050 kg

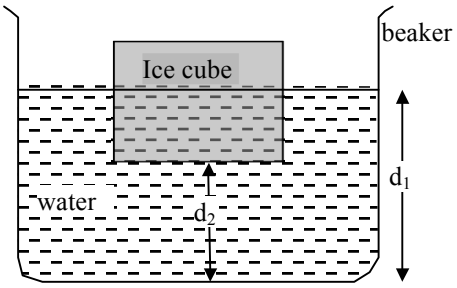


Figure 8

22 An ice cube with mass, m kg is floating on water as shown in Figure 8. The depth of water is d_1 and the area of cross section the beaker is A. The distance between bottom of the ice cube and the base of the beaker is d_2. When the ice cube melts, what is the pressure of water acting on the base of the beaker?

[density of water is ρ and acceleration due to gravity is g]

A $\rho g d_1$ **B** $\rho g d_2$ **C** $\rho g(2d_1 - d_2)$ **D** $\rho g(d_1 - d_2) + \frac{mg}{A}$ **E** $\rho g d_1 + \frac{mg}{A}$

23 A cube of ice is floating in a salt solution of density 1.25 times the density of pure water in a beaker. When the ice melts, the level of the solution in the vessel

A rises **B** falls

C remains unchanged **D** falls at first and then rises to the same height as before

24 A 100 g of ice at 0°C is mixed with 100 g of water at 80°C. The final temperature of the mixture will be [specific heat capacity for water = 4.2 kJ kg^{-1} K^{-1} , specific latent of fusion of ice = 2.26×10^3 kJ kg^{-1}]
A 0 °C **B** 20 °C **C** 40 °C **D** 60 °C **E** - 230 °C

25 According to the kinetic theory of gases, an increase in the pressure of a fixed mass of gas corresponds to
A an increase in temperature if the volume is held constant
B an increase in volume if temperature is held constant
C an increase in density if the volume is held constant
D a decrease in temperature if the volume is held constant

26 Two thousand joules of heat is added to a solid sample. The solid does not lose any heat to the environment. At the end of this process, however, the sample's temperature is exactly the same as it was before the heat was added. This most likely indicates that the
A sample is in the process of melting. **B** sample has a low specific heat.
C sample has reached its heat capacity. **D** sample is a thermal insulator.

27 A container holding 1.2 kg of water at 20.0 °C is placed in a freezer that is kept at –20.0 °C. The water freezes and comes into thermal equilibrium with the interior of the freezer. How much heat is extracted from the water in this process?
[Specific heat capacity of water = 4200 J kg^{-1} K^{-1}, specific heat capacity of ice = 2100 J kg^{-1} K^{-1}, specific latent heat of fusion of ice = 3.35×10^5 J kg^{-1}]
A 48 000 J **B** 170 000 J **C** 400 000 J **D** 550 000 J **E** 350 000 J

28 What is the frequency of light that has a wavelength of 6.00×10^2 nm in water if the refractive index of water for this light is 1.33?
A 2.25×10^{14} Hz **B** 3.76×10^{14} Hz **C** 5.00×10^{14} Hz
D 6.65×10^{14} Hz **E** 7.25×10^{14} Hz

29 An object is placed between the focal point and twice the focal length of a converging lens. The image formed will be
A real and upright **B** real and inverted **C** virtual and upright **D** virtual and inverted

30 In which of the following could one observe a real inverted image?
I a convex spherical mirror **II** a plane mirror **III** a concave spherical mirror

A I only **B** III only **C** I and II only **D** II and III only

31 Sunlight passes through a crystal and emerges vibrating in only one plane. This illustrates the phenomenon of
A polarization **B** diffraction **C** refraction **D** interference

32 The edge of a spherical concave lens is uniformly blackened so that the aperture of the lens is a circle with diameter 4.0 cm. When a beam of light passes though the whole of the aperture of the lens parallel to the principal axis, a circular bright spot with diameter 20.0 cm is formed on the screen situated 60.0 cm from the lens. What is the focal length of the lens?
A 10.7 cm **B** 12.0 cm **C** 15.0 cm **D** 20.0 cm **E** 60.0 cm

33 When certain light rays pass from a vacuum into a block of an unknown material, the measured index of refraction of the material is 3.50. What is the speed of light inside the block?
A 1.0×10^7 m s^{-1} **B** 4.8×10^7 m s^{-1} **C** 8.6×10^7 m s^{-1} **D** 1.9×10^8 m s^{-1} **E** 1.1×10^9 m s^{-1}

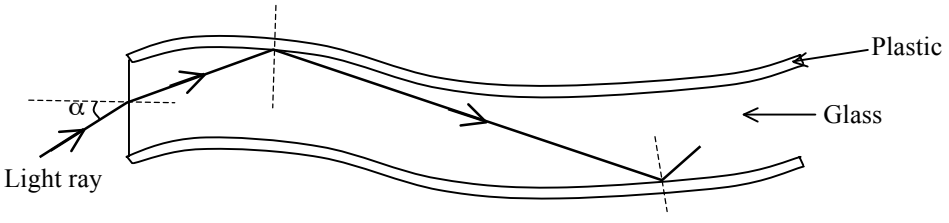


Figure 9

34 An optical fiber has a circular glass core and is covered by thin uniform layer of plastic. The refractive index of the glass core is 1.460 and the refractive index of plastic is 1.440. Figure 9 shows a light ray passing through the optical fiber. What is the maximum value of the incident angle α so that the light ray shown can be propagated through the fiber?

A 9.5^o **B** 13.9^o **C** 30.4^o **D** 46.0^o **E** 80.5^o

35 Complete the following sentence: The term *coherence* relates to the

A phase relationship between two waves **B** amplitude of two waves
C polarization state of two waves. **D** frequency of two waves

36 A double slit is illuminated with monochromatic light of wavelength 6.00×10^2 nm. The m = 0 and m = 1 bright fringes are separated by 3.0 cm on a screen which is located 4.0 m from the slits. What is the separation between the slits?

A 4.0×10^{-5} m **B** 5.3×10^{-5} m **C** 8.0×10^{-5} m **D** 1.2×10^{-4} m **E** 1.6×10^{-4} m

37 Which one of the following statements concerning a convex mirror is true?

A It can form a real image.
B It must be spherical in shape.
C The image will always be inverted relative to the object.
D The image it produces is closer to the mirror than it would be in a plane mirror for the same object distance.

38 Complete the following sentence: The various colors of visible light differ in

A frequency only. **B** wavelength only.
C their speeds in a vacuum. **D** frequency and wavelength.

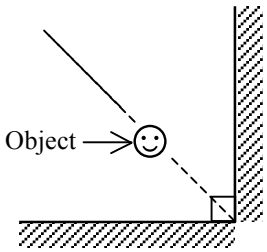


Figure 10

39 An object is placed near two perpendicular plane mirrors as shown in the Figure 10. How many images will be formed?

A 1 **B** 2 **C** 3 **D** 4 **E** 8

40

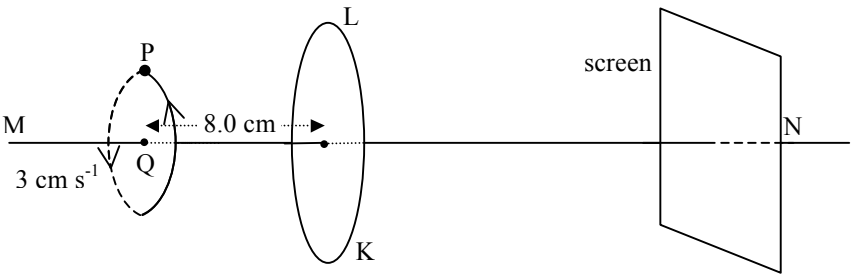


Figure 11

Figure 11 shows a point Q situated 8.0 cm from the centre O of a lens LK. A point light source P is moving with speed 3.0 cm s^{-1} around point Q in circular path in anticlockwise direction. The plane of the circular path of P is parallel to the plane of the lens. The point image of P formed on the plane screen is moving in a circular path with speed 12.0 cm s^{-1}. Which of the following deductions are correct?

	Types of lens	Focal length	Direction of image's motion
A	convex	6.4 cm	anticlockwise
B	convex	6.4 cm	clockwise
C	convex	32.0 cm	clockwise
D	concave	6.4 cm	anticlockwise
E	concave	32.0 cm	clockwise

41 The frequency of a simple pendulum is f_1. When the length l of the pendulum is increased to $2l$, the frequency is f_2. The ratio of $\frac{f_1}{f_2}$ is

A $\frac{1}{\sqrt{2}}$ **B** $\frac{1}{2}$ **C** 2 **D** $\sqrt{2}$ **E** $2\sqrt{2}$

42 A cellular telephone transmits electromagnetic waves at a frequency of 935 MHz. What is the wavelength of these waves?

A 0.0106 m **B** 0.321 m **C** 0.642 m **D** 1.22 m **E** 321 m

43 A distant space probe is programmed to emit a radio signal toward Earth at regular time intervals. One such pulse arrives on Earth 2.92 s after it is emitted from the probe. What is the approximate distance from the Earth to the probe?

A 4.12×10^8 m **B** 6.94×10^8 m **C** 7.40×10^8 m **D** 8.76×10^8 m **E** 1.75×10^9 m

44 The 2006 Noble Prize for Physics is regarding the background radiation in the universe which are remnants from the Big Bang. The Big Bang is a cosmological model in which the universe has been expanding for around 13.7 billion years, originating from a tremendously dense and hot state. The wavelength of this background electromagnetic radiation is in the millimetre range, hence it is a

A gamma ray **B** microwave **C** ultraviolet ray **D** sound wave

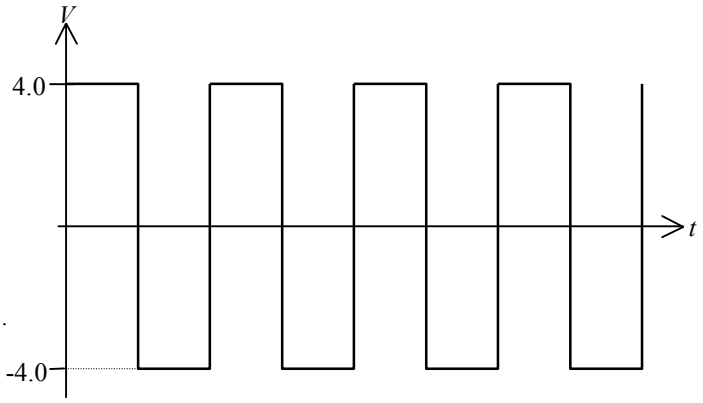


Figure 12

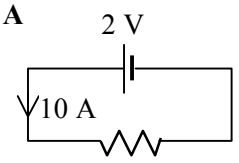
45 Figure 12 shows the output of an electrical source. The root mean square voltage of the source is

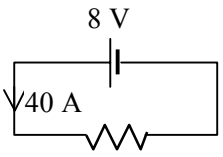
A 0 V **B** 2.8 V **C** 4.0V **D** 8.0 V **E** 11.3 V

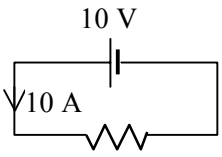
46 A current of 5 A exists in a 10-ohm resistor for 4 minutes. How many coulombs pass through any section of the resistor in this time?

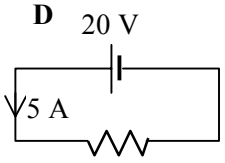
A 1.2 coulombs **B** 12 coulombs **C** 120 coulombs **D** 200 coulombs **E** 1200 coulombs

47 Which one of the following circuits has the largest resistance?

A


B


C


D


48 A wire of resistance 2 Ω is stretched uniformly to twice its original length. The resistance of the new wire will be

A 1 Ω **B** 2 Ω **C** 4 Ω **D** 8 Ω **E** 10 Ω

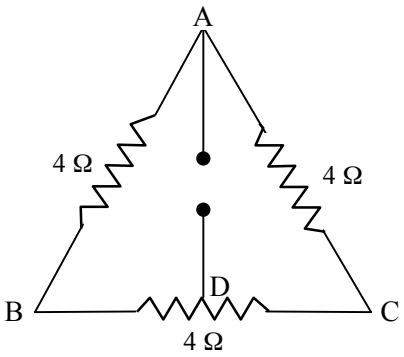


Figure 13

49 Three resistances of 4 Ω each are connected as shown in the Figure 13. If the point *D* divides the resistance into two equal halves, the resistance between points *A* and *D* will be

A $\frac{1}{3}$ Ω **B** 2 Ω **C** 3 Ω **D** 6 Ω **E** 12 Ω

50 When four resistors of type A are connected in parallel, they are equivalent to two resistors of type B connected in series. How many resistors of type B must be connected in series to equal to the resistance of a single resistor of type A?

A 1 **B** 2 **C** 4 **D** 8 **E** 16

51 The smallest resistance that can be obtained by combining *n* resistors, each of resistance *R* is

A n^2R **B** nR **C** $\frac{R}{n}$ **D** $\frac{R}{n^2}$

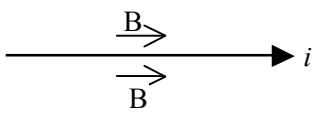
52 Which one of the following statements concerning resistance is true?

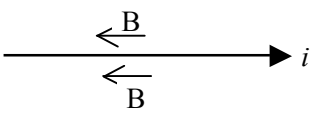
A The resistance of a semiconductor increases with temperature.
B Resistance is a property of resistors, but not conductors.
C The resistance of a metal wire changes with temperature.
D The resistance is the same for all samples of the same material.

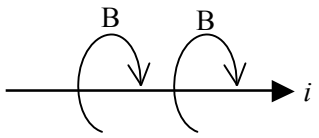
53 A particle A with mass *m* and charge +2*e* was accelerated from rest across a potential difference *V* in vacuum and achieved a maximum speed v_A. Another particle B with mass 2*m* and charge +1*e* was accelerated from rest across a potential difference 2*V* in vacuum and achieved maximum speed v_B. The ratio of v_A: v_B is

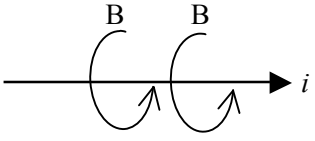
A 1: $\sqrt{2}$ **B** 1: 2 **C** 1:1 **D** $\sqrt{2}$: 1 **E** $2\sqrt{2}$: 1

54 Which of the following depicts the direction of magnetic field lines, B, generated by a current *i* flowing in a straight line?

A


B


C


D


55 Which one of the following statements concerning the magnetic field well inside a long, current carrying solenoid is true?

A The magnetic field is zero.
B The magnetic field is non-zero and nearly uniform.
C The magnetic field is independent of the number of windings.
D The magnetic field is independent of the current in the solenoid.

56 The current in the secondary coil of a step-up transformer is 0.86 A when the current in the primary coil is 4.8 A. Determine the turns ratio, $\frac{N_s}{N_p}$, of the transformer.

A 0.18 **B** 0.12 **C** 2.4 **D** 4.1 **E** 5.6

57 A charged particle is moving in a uniform, constant magnetic field. Which one of the following statements

concerning the magnetic force exerted on the particle is false?

A It does no work on the particle. **B** It increases the speed of the particle.
C It changes the velocity of the particle. **D** It can act only on a particle in motion.

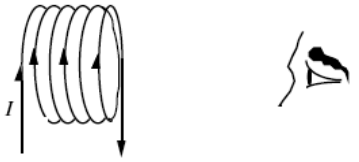
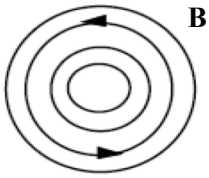
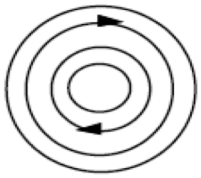
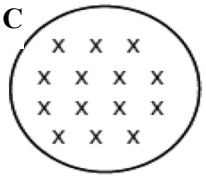
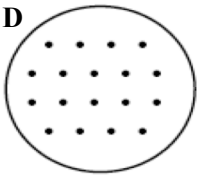
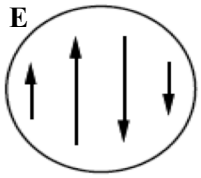


Figure 14

58 A long wire that carries a current *I* is bent into five loops as shown in Figure 14. If the observer could "see" the magnetic field inside this arrangement of loops, how would it appear?

A  **B**  **C**  **D**  **E** 

59 Which one of the following statements concerning transformers is false?

A Their operation makes use of mutual induction.
B They are an application of Faraday's and Lenz's laws.
C A transformer can function with either an ac current or a steady dc current.
D A transformer that steps down the voltage, steps up the current.

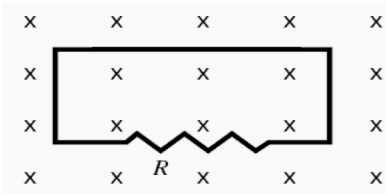


Figure 15

60 Figure 15 shows a uniform magnetic field that is normal to the plane of a conducting loop, which has a resistance *R*. Which one of the following changes will cause an induced current to flow through the resistor?

I decreasing the magnitude of the magnetic field
II increasing the magnitude of the magnetic field
III rotating the loop through 90° about an axis in the plane of the paper

A I only **B** I and II only **C** III only **D** I, II and III only

61 Which one of the following statements concerning permanent magnets is false?

A All permanent magnets are surrounded by a magnetic field.
B The direction of a magnetic field is indicated by the north pole of a compass.
C Magnetic field lines outside a permanent magnet originate from the north pole and end on the south pole.
D When a permanent magnet is cut in half, one piece will be a north pole and one piece will be a south pole.

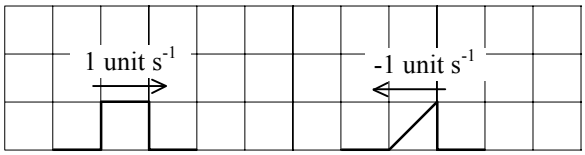
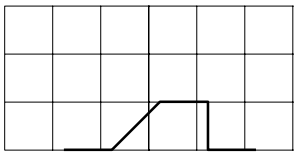
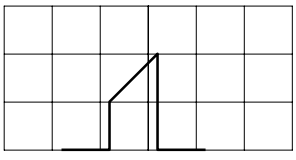
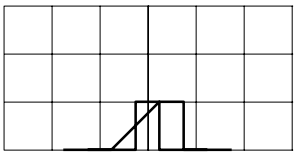
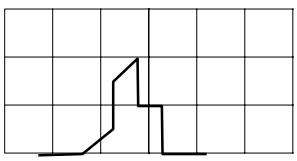
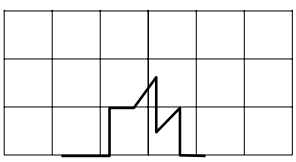


Figure 16

62 Figure 16 shows two pulses moving in opposite directions along a string are shown. What will the pulse look like after 3.25 s?"

A  **B**  **C** 

D  **E** 

63 Which of the following particles carry charge?
I Alpha particle **II** Beta particles **III** Photons

A I only **B** III only **C** I and II only **D** II and III only

64 The ratio ^{14}C : ^{12}C in a living plant is 1 : $1x10^{12}$. This ratio is decreasing after the plant dies because there is no replacement for the radioactive ^{14}C which decays. The half life of ^{14}C is 5600 years. The ratio of ^{14}C : ^{12}C in a sample of the ancient plant is 1 : $1x10^{13}$. What is the age of the ancient plant?
A 2800 years **B** 5600 years **C** 11200 years **D** 16800 years **E** 18600 years

65 The half-life of a radioactive element is 400 years. If a given sample of this element is allowed to decay for 1,200 years, what fraction of the original radioactive atoms will remain?
A $\frac{1}{16}$ **B** $\frac{1}{8}$ **C** $\frac{1}{4}$ **D** $\frac{3}{4}$ **E** $\frac{7}{8}$

66

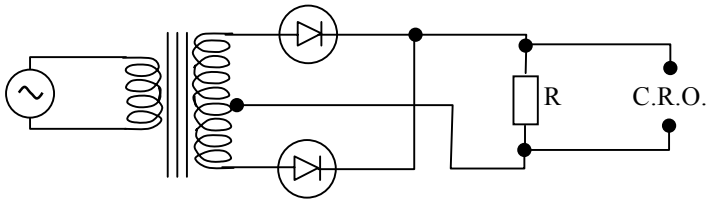
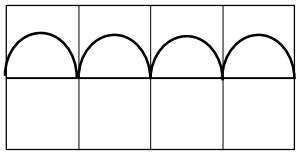


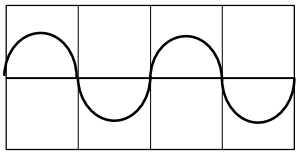
Figure 17

An a.c. source is connected to the primary of a transformer with the secondary connected to two diodes and a resistor as shown in Figure 17. Which of the following shows the oscilloscope trace for the output?

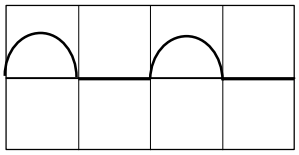
A



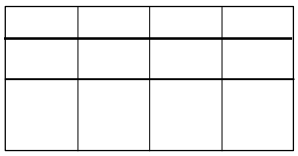
B



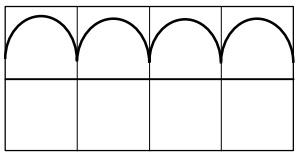
C



D



E



67 Initially when t = 0 minute, 16.00 mg of a radioactive source X is put into an enclosed container. The half life of X is 2.0 minutes. When t = 4.0 minutes and t = 8.0 minutes, 8.00 mg of a radioactive source X is added into the container respectively. What is the mass of the radioactive source X remaining in the container at t = 12.0 minutes?
A 0.25 mg **B** 0.75 mg **C** 2.00 mg **D** 2.50 mg **E** 2.75 mg

68 One small sample of a liquid form radioisotope which emits 1.5 x 10^4 β-particles per minute is mixed with a non radioactive liquid X. After a period of 32 hours, one liter of the mixer is tested and it emits 20 β-particles per minute. If the half life of the radioisotope is 8 hours, what is the volume of liquid X?
A 4 liters **B** 47 liters **C** 80 liters **D** 750 liters **E** 938 liters

69 Which one of the following statements is the best explanation as to why nuclear fusion is not at present used to generate electric power?
A Fusion produces too much radiation.
B Fusion requires isotopes that are scarce.
C Fusion processes can result in nuclear explosions.
D Fusion requires very high temperatures that are difficult to sustain.

70 Radiation or (and) particles emerge(s) from a radioactive sample. These products from the sample are allowed to pass through a narrow slit and may be considered a beam. The beam is passed between two plates that carry opposite electrical charge. The experimental region contains no magnetic fields. It is observed that the beam is deflected toward the negatively charged plate as shown in Figure 18.

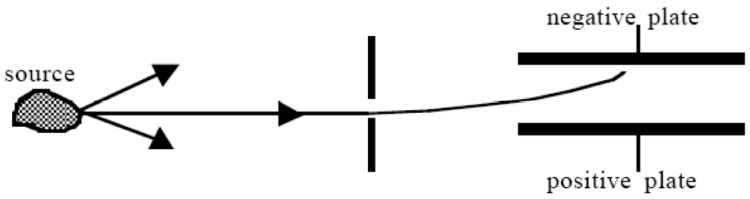


Figure 18

Which one of the following statements is the best conclusion for this situation?

A The beam could be either γ rays or α rays.
B The beam is only γ rays.
C The beam could be either α rays or β+ rays.
D The beam could be either γ rays or β- rays.