SINGAPORE JUNIOR PHYSICS OLYMPIAD 2018
GENERAL ROUND

17 May 2018, Thursday
1500 – 1700
Time Allowed: **2 Hours**

INSTRUCTIONS

1. **Read the instructions on this page** but **DO NOT TURN the page** until you are told to do so by the invigilator.
2. This paper contains **50** multiple choice questions and **14** printed pages (including this cover page). Each of the questions or incomplete statements is followed by five suggested answers or completions. **Select only the best** in each case and then **shade** the corresponding bubble on the answer sheet.
3. Use **2B pencil** only to shade the bubbles on the answer sheet, and make sure any stray markings are properly erased.
4. Please **submit both** the **question paper** and the **answer sheet**. **Only** the **answer sheet** will be **marked**. Answers written anywhere else will not be marked.
5. **Fill in your NRIC number on the answer sheet now.** Write your name and school on the answer sheet now.
6. **Scientific calculators** are **allowed** in this test. **Graphing** calculators are **not** allowed.
7. Answer **ALL** questions. Marks will **NOT** be deducted for wrong answers so use your intuition, guess or just eliminate the obviously wrong and choose from the remainder randomly.
8. A general data sheet is given below. You may **detach the data sheet when the competition starts** so that you can refer to it easily.

GENERAL DATA SHEET

Acceleration due to gravity at Earth surface,	g	$= 9.80$ m s^{-2} = $|\mathbf{g}|$
Universal gravitational constant,	G	$= 6.67 \times 10^{-11}$ m^3 kg^{-1}s^{-2}
Universal gas constant,	R	$= 8.31$ J mol^{-1} K^{-1}
Vacuum permittivity,	ε_0	$= 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}
Vacuum permeability,	μ_0	$= 4\pi \times 10^{-7}$ T m A^{-1}
Atomic mass unit,	u	$= 1.66 \times 10^{-27}$ kg
Speed of light in vacuum,	c	$= 3.00 \times 10^{8}$ m s^{-1}
Speed of sound in air,	v_s	$= 340$ m s^{-1}
Charge of electron,	e	$= 1.60 \times 10^{-19}$ C
Planck's constant,	h	$= 6.63 \times 10^{-34}$ J s
Mass of the Earth	M_E	$= 5.92 \times 10^{24}$ kg
Mass of electron,	m_e	$= 9.11 \times 10^{-31}$ kg $= 0.000549u$
Mass of proton,	m_p	$= 1.67 \times 10^{-27}$ kg $= 1.007u$
Mass of deuteron,	m_p	$= 3.34 \times 10^{-27}$ kg $= 2.014u$
Rest mass of alpha particle,	m_α	$= 4.003u$
Boltzmann constant,	k	$= 1.38 \times 10^{-23}$ J K^{-1}
Avogadro's number,	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
Standard atmosphere pressure,	P_0	$= 1.01 \times 10^{5}$ Pa
Density of water,	ρ_w	$= 1000$ kg m^{-3}
Specific heat (capacity) of water,	c_w	$= 4.19 \times 10^{3}$ J kg^{-1} K^{-1}
Stefan-Boltzmann constant,	σ	$= 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
Radius of the sun,	r_S	= 696,000 km
Radius of the earth,	r_E	= 6370 km
Distance between sun and earth,	r_{SE}	= 150,000,000 km
Acceleration due to gravity at the sun's surface,	g_s	= 28.02 g
Temperature on the surface of the sun	T_s	= 5780K

1. The figure shows the potential energy $V(x)$ as a function of molecular separation x for a diatomic molecule of reduced mass μ.

If $V(x) = V_0(1-e^{-(x-x_0)/\delta})^2 - V_0$, the vibrational frequency f at the equilibrium position is ___.

(Hint: This series expansion may be useful. $e^x \approx 1 + x + \frac{x^2}{2!}$)

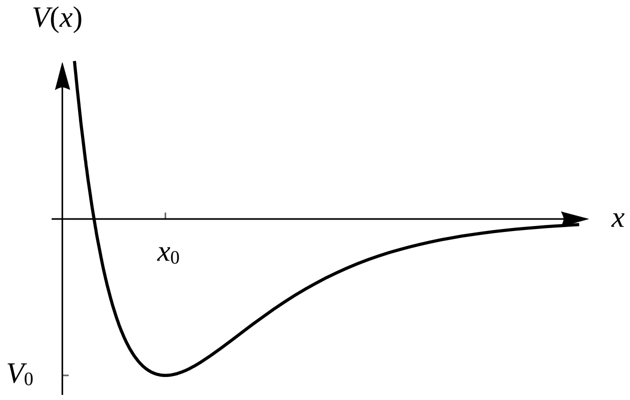
A. $\frac{2V_0}{\mu\delta}$

B. $\frac{V_0}{2\pi^2\mu\delta}$

C. $\sqrt{\frac{2V_0}{\mu\delta^2}}$

D. $\frac{1}{2\pi}\sqrt{\frac{2V_0}{\mu\delta^2}}$

E. $\frac{1}{2\pi}\sqrt{\frac{V_0}{\mu\delta^2}}$



2. A tiny spherical raindrop of diameter D = 0.1 mm experiences a linear drag force while falling at speed v, given by $F_{drag} = cv$, where $c = 1.55 \times 10^{-6}$ N s m^{-1}. What is its terminal speed?

A. 1.7 mm / s
B. 3.3 mm / s
C. 8.5 mm / s
D. 26 mm / s
E. 33 mm / s

3. A plumb line is held steady while being carried in a moving train. The mass of the plumb bob is m, and the train is accelerating in the forward direction at 0.5g. What is the tension in the string?

A. 0.5 mg
B. 1.12 mg
C. 1.22 mg
D. 2 mg
E. Cannot be determined from the given information.

4. A sphere rolls without slipping down a rough inclined plane. The gain in rotational kinetic energy is due **directly** to the work done by ______.

A. Static friction
B. Kinetic friction
C. Weight
D. Normal contact force
E. Air resistance

5. A thin wire is bent into the form of a three-sided shape as shown below. Each segment has equal length l. The height of the centre of mass from the bottom of the shape is ______.

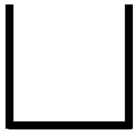
A. $l/2$

B. $2l/3$

C. $l/3$

D. $l/4$

E. $2l/5$



6. A 4 kg sphere rests on the smooth parabolic surface which is given by the equation $y = 2.5\,x^2$. The sphere just touches the surface at $(x, y) = (0.4\text{ m}, 0.4\text{ m})$. Determine the mass m_B of block B needed to hold the sphere in equilibrium.

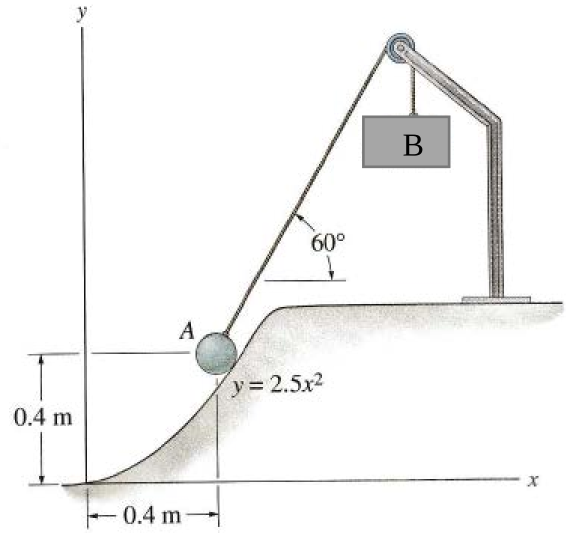
A. 4.14 kg

B. 3.75 kg

C. 3.58 kg

D. 2.93 kg

E. 2.14 kg



7. A bug is just about to slip on a circular turntable of radius R rotating at constant angular velocity. The bug is halfway between the centre and the edge and the coefficient of static friction is 1/4. What is the acceleration of the bug?

A. $3g$

B. $2g$

C. $3g/2$

D. $g/2$

E. $g/4$

8. The height of a circular geosynchronous orbit (24 hr period) from the earth's surface is approximately ___ Earth radii. (Hint: You may need the gravitational constant, mass of the Earth and the gravitational acceleration at the surface of the Earth. These are given in the list of constants.)

A. 3

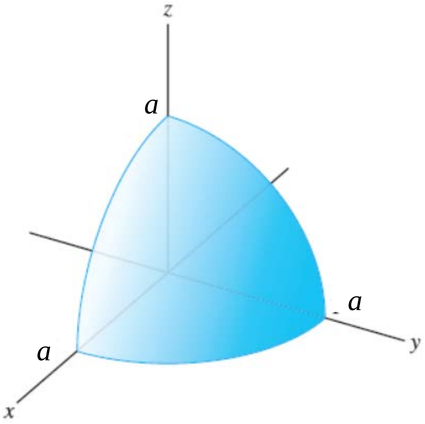
B. 4

C. 5

D. 6

E. 7

9. The moment of inertia of a solid sphere of mass M and radius a, about an axis passing through its centre, is $(2/5)Ma^2$. The mass of a solid uniform octant (one-eighth) of a sphere of radius a, is m. The moment of inertia about an axis along one of the straight edges (e.g. z axis) is ____.



A. $\frac{4}{3}ma^2$

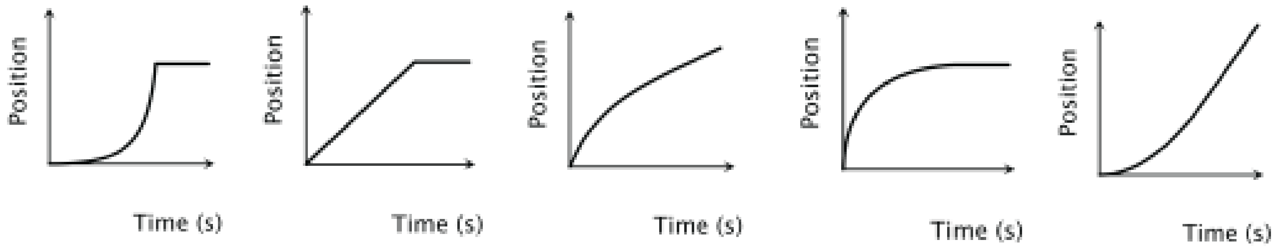
B. $\frac{2}{5}ma^2$

C. $\frac{3}{8}ma^2$

D. $\frac{1}{8}ma^2$

E. $\frac{1}{20}ma^2$

10. The position of an object moving along a linear track is plotted as a function of time. It started from rest and underwent a positive acceleration for some time, followed by a constant velocity. Which of the following graphs correctly shows this situation?

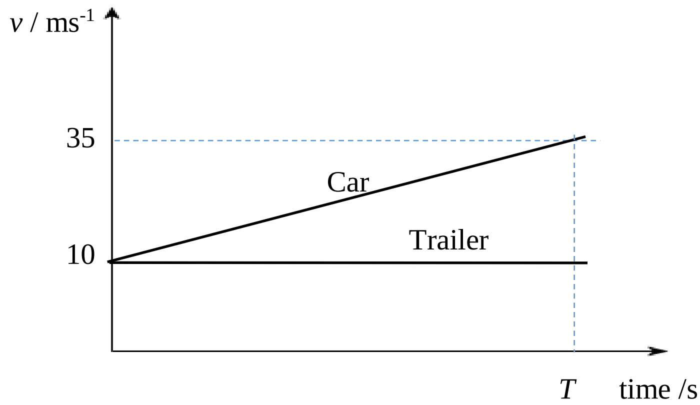


A. B. C. D. E.

11. The minimum time T for a car to safely overtake a long trailer is measured from the time the front of the car is level with the rear of the trailer, until the rear of the car is one full car-length ahead of the trailer.

The car is 3.5 m long and the trailer is 15.0 m long.

The graph shows the speed-time graphs of the car and the trailer. What is the minimum time T?



A. 2.16 s

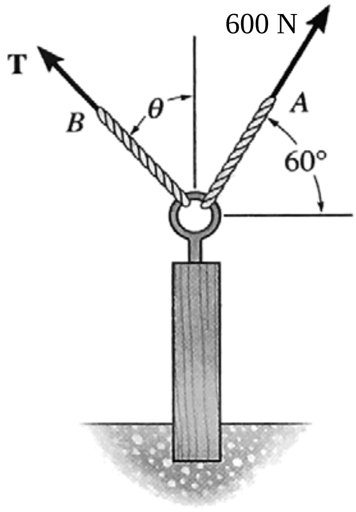
B. 1.76 s

C. 1.48 s

D. 0.88 s

E. 0.64 s

12. A wooden peg is to be pulled out of the ground using two ropes A and B. Rope A is subject to a force of 600 N at 60º to the horizontal. Rope B is pulled at a fixed angle θ to the vertical. If the resultant force acting on the post is to be 1600 N vertically, what should be the force T on rope B?



A. 1121 N
B. 1334 N
C. 1400 N
D. 1924 N
E. 2040 N

13. Travelling with an initial speed of 70 km/h, a car accelerates at 6000 km/h^2 along a straight road. How long will it take to reach a speed of 120 km/h?

A. 30 s
B. 45 s
C. 60 s
D. 70 s
E. 180 s

14. Two blocks move towards each other on a smooth table with the velocities as shown. Block A has mass 5 kg and moves at 2 m/s to the right. Block B has mass 2 kg and moves at 5 m/s to the left. The coefficient of restitution e is the ratio of the final relative speed of separation to the initial relative speed of approach of two colliding objects. Take rightwards as positive. If e = 0.5, what is the velocity of block B after impact?

A. - 2.5 m/s
B. - 1.0 m/s
C. 0 m/s
D. 1.0 m/s
E. 2.5 m/s

15. The twitch in an arm muscle develops a force F which can be measured as a function of time t, given by $F = F_0\left(\frac{t}{T}\right)e^{-t/T}$, where F_0 and T are constants. The function is plotted in the figure. If the ratio $t_0/T = 1$, what is the impulse developed between time $t = 0$ and time $= t_0$? (Hint: Make use of this integral. $\int_0^a xe^{-x}dx = 1-(1+a)e^{-a}$.)

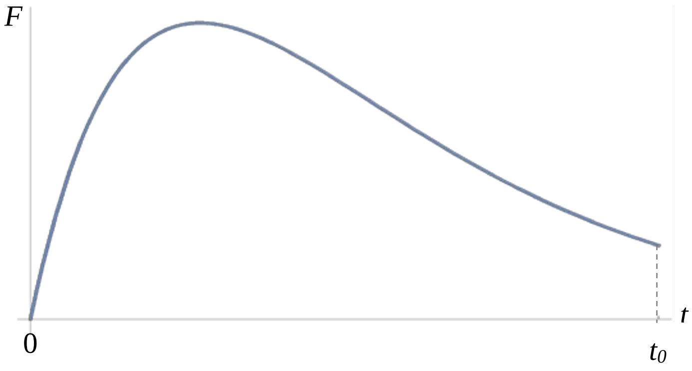
A. $F_0(T(1/e)+t_0(1/e))$

B. $F_0(T(1/e)-t_0(1/e))$

C. $F_0(T(1-1/e)+t_0(1/e))$

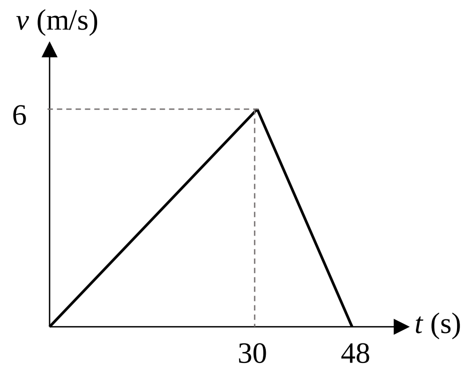
D. $F_0(T(1-1/e)-t_0(1/e))$

E. Indeterminate



Q 16 and 17 refer to the following.

A car travels along a straight road with the speed shown by the v-t graph.



16. What is the acceleration of the car from t=30 to t=48 s?

A. - 54 m / s^2

B. 48 m / s^2

C. - 3.0 m / s^2

D. 3.0 m / s^2

E. - 0.33 m / s^2

17. What is the total displacement of the car after 48 s?

A. 36 m

B. 48 m

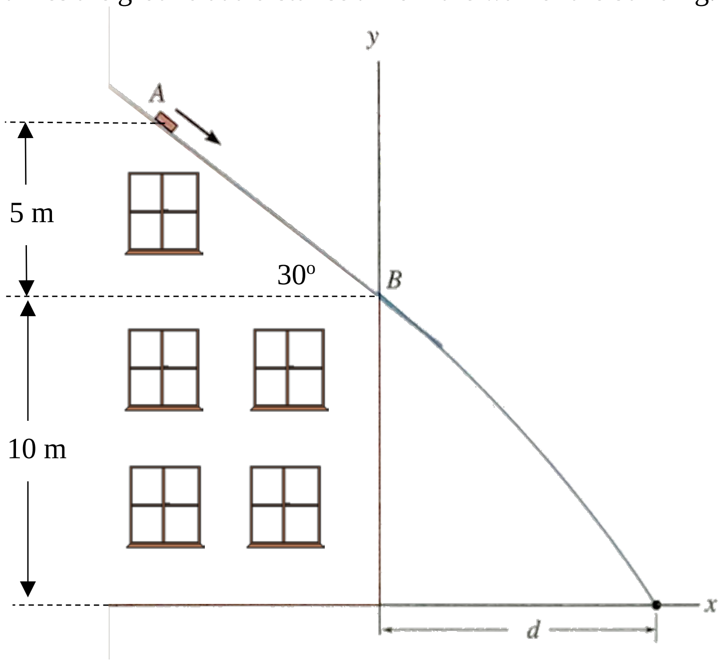
C. 144 m

D. 180 m

E. 210 m

18. A 2 kg block slides down a smooth roof which is angled at 30° to the horizontal. When it reaches A, it has a speed of 2.0 m/s. It leaves the surface of the roof at B and strikes the ground at a distance *d* from the wall of the building. What is the distance *d* ?

A. 3.96 m
B. 8.66 m
C. 8.78 m
D. 17.3 m
E. 17.8 m

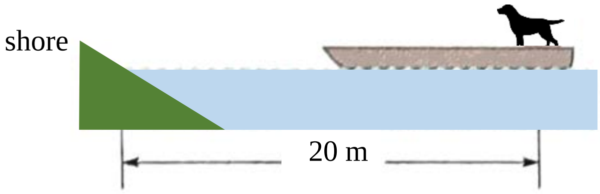


19. **Two** adventurous Physics students, each weighing 60 kg, jump off a 43 m high bridge on a Bungee cord. The length of the cord is such that the students together will *just* touch the water and rebound. While Bungee cords become softer (more elastic) with increasing extension, for our calculations we can approximate the cord as having a constant stiffness of k = 330 N/m, and we can ignore the height of the students and where the cord is tied on their body. What is the unstretched length of the cord?

A. 10.0 m
B. 17.5 m
C. 25.5 m
D. 32.5 m
E. 40.0 m

20. A dog weighing 10 kg is standing on a flatboat so that he is 20 m from the shore. The boat weighs 40 kg and has uniform mass distribution. The dog walks 8.0 m on the boat towards the shore and stops. For this calculation, one can assume no friction or drag between the boat and the water. How far is the dog from the shore now?

A. 12.0 m
B. 13.6 m
C. 14.0 m
D. 16.8 m
E. 29.8 m

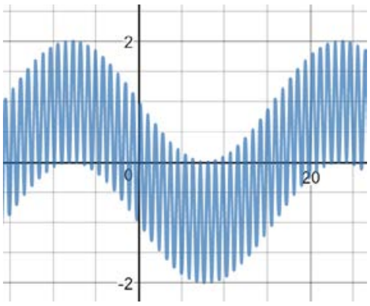


21. The bob of a simple pendulum travels 2 m in one complete oscillation in a time of 2.000s. Assuming that **damping is negligible**, when the same pendulum is made to travel 4 m in one complete oscillation, the time taken is _______.
A. 4.000 s
B. More than 2.000 s
C. 2.000 s
D. Less than 2.000 s
E. 1.000 s

22. A free electron oscillates about a fixed position in a uniform, oscillating electric field with frequency 10^9 Hz and amplitude $10^4\ \mathrm{Vm^{-1}}$. What is the distance travelled in one complete oscillation?
A. 0 μm
B. 45 μm
C. 90 μm
D. 135 μm
E. 180 μm

23. In a plum pudding model of the atom, suppose that there is a solid ball of uniformly distributed positive charge with total charge +e and radius $a = 53 \times 10^{-12}$ m, and that an electron "oscillates" in a tunnel through the center of the sphere. What is **the** time taken for an electron starting from rest somewhere in the tunnel to reach the center of the sphere? For this problem consider only electrostatic force and model the electron as a point.
A. 0.038 fs
B. 0.038 ps
C. 0.038 ms
D. 0.038 min
E. Not enough information.

24. Mr. Oh describes **a** "simple harmonic oscillator" by the equation $y = 2.0\cos(3.5t)\sin(3.7t)$, where y is in metres and t is in seconds. Which of the following statement is best?
A. This simple harmonic oscillator has two very similar frequencies.(ratio <2)
B. This simple harmonic oscillator has one period and one frequency.
C. This simple harmonic oscillator has two very different frequencies.(ratio >2)
D. This simple harmonic oscillator has harmonics.
E. This cannot even be a simple harmonic oscillator.



25. Mr. Oh describes another "simple harmonic oscillator" by the equation $y = 3.0\cos(3.6t)\sin(3.6t)$, where y is in metres and t is in seconds. What is the frequency of the "simple harmonic oscillator"?
A. This cannot even be a simple harmonic oscillator
B. 0.57 Hz
C. 1.1 Hz
D. 3.6 Hz
E. 7.2 Hz

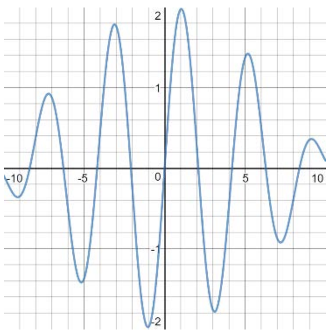
26. Madam Wan describes a "wave" by the following equation $y = 2.0 \cos(1.5x + 3.6t)$, where y and x is in metres and t is in seconds. What is the wavelength of the wave?

A. 1.5 m
B. 1.7 m
C. 2.0 m
D. 3.6 m
E. 4.2 m

27. Ms. Toh describes a "wave" with the following equation $y = 2.0 \cos(1.5x + 3.6t)$, where x is in metres and t is in seconds. What is the direction of the waves phase velocity?

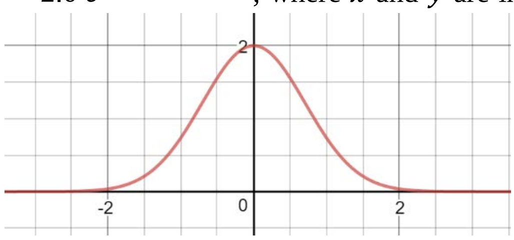
A. positive x-direction
B. negative x-direction
C. positive y direction
D. negative y-direction
E. positive z-direction

28. Dr. Dre describes a "wave" by the following equation where y and x are in metres and t is in seconds. $y = 2.0 \cos(0.15x + 0.36t)\sin(1.5x + 3.6t)$, Which of the following statement is best?



A. This wave has two very similar frequencies.(ratio <2)
B. This wave has two very different frequencies.(ratio >2)
C. This wave has one overall period and one frequency.
D. This is two waves with two different speeds.
E. This is not even a wave.

29. Monsieur Fourier describes a "wave" by the following equation $y = 2.0\, e^{-(1.5x + 3.6t)^2}$, where x and y are in metres and t is in seconds. Which of the following is true?



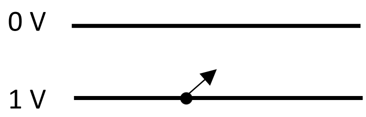
A. The wave speed is 1.8 ms^{-1}
B. The wave speed is 2.4 ms^{-1}
C. The wave speed is 3.6 ms^{-1}
D. The wave speed is 7.2 ms^{-1}
E. None of the above

30. An ocean wave strikes a sea head on (i.e. the surface of the wall is parallel to the plane wavefronts). The incoming wave travels 53 cm/s and has a period of 6.4 s. The wave has an antinode at the wall. How far from the wall is the nearest node in the standing wave setup?

A. 0.59 m
B. 0.74 m
C. 0.85 m
D. 1.1 m
E. 1.7 m

31. An electron is emitted at an angle of 45 degrees from the surface of a metal plate as shown in the figure (other details also shown in the diagram). The electron's initial **kinetic energy** is 1.5eV. A uniform electric field is applied such that the potential difference between the two plates is 1V. Assume the plates **are infinitely wide**. The electron _____________.

A. moves in a parabolic trajectory and returns to the plate where it started
B. moves in a parabolic trajectory and hits the second plate
C. moves in a circular trajectory and hits the second plate
D. moves in a circular trajectory and returns to the plate where it started
E. may or may not hit the other plate depending on the distance between the plates

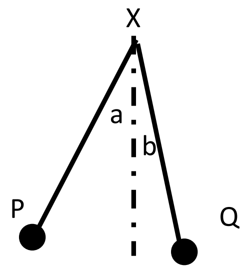


32. A proton on the **surface of the earth** travels upwards in a downwards uniform electric field $E = 2.5 \times 10^{-10}\text{Vm}^{-1}$. Calculate the **net** force acting on the proton.

A. 4.0×10^{-29} N upwards
B. 4.0×10^{-29} N downwards
C. 2.0×10^{-27} N downwards
D. 2.0×10^{-26} N upwards
E. 1.6×10^{-26} N downwards

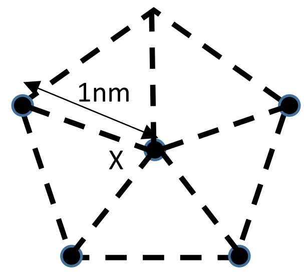
33. The diagram shows two small charged spheres P and Q of small mass, which are hung by identical fine nylon threads from a fixed point X. It is found that, in equilibrium, the angle a is greater than the angle b. Which one of the following statements is **best**?

A. The charge on P is numerically smaller than that on Q.
B. The charge on P is numerically greater than that on Q.
C. The mass of P is less than that of Q.
D. The mass of P is greater than that of Q.
E. The charges on P and Q are both positive.



34. Consider five protons as shown in the diagram. One proton is at the center, X, of the regular pentagon while the remaining four are at the vertices. What is the force acting on the proton at X due to the other four protons?

A. 2.3×10^{-10}N upwards
B. 4.6×10^{-10}N downwards
C. 6.9×10^{-10}N upwards
D. 9.2×10^{-10}N downwards
E. 1.2×10^{-9}N upwards



35. Five protons are fixed at the vertices of a regular pentagon. A sixth proton, P, moves from very far away to the center of the pentagon. The electrical potential energy associated with proton P when it is at the center of the pentagon ___________________.

A. has not changed from what it was initially as the initial and final force acting on the proton P is 0
B. cannot be calculated as it depends on the exact 3-D path which the proton P takes
C. cannot be calculated as it depends on the initial and final speed of the proton P
D. may be calculated as 5 times the energy stored in a system of two point charges
E. may be calculated as 6 times the energy stored in a system of one point charge

36. Two protons initially very far from each other move towards each other, each with an initial speed $u = 3.0 \times 10^5 \text{ms}^{-1}$. Consider only the electrostatic forces between the particles. How close together can they get?

A. 7.7×10^{-12}m
B. 1.5×10^{-12}m
C. 3.1×10^{-12}m
D. 6.2×10^{-12}m
E. 12×10^{-12}m

37. A proton initially very far away, moves with initial speed $u = 6 \times 10^5 \text{ms}^{-1}$ towards an initially stationary proton. Consider only the electrostatic forces between the particles. How close together can they get?

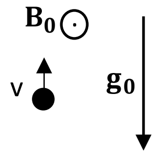
A. 7.7×10^{-12}m
B. 1.5×10^{-12}m
C. 3.1×10^{-12}m
D. 6.2×10^{-12}m
E. 12×10^{-12}m

38. An electron initially very far away moves with initial speed $u = 3 \times 10^6 \text{ms}^{-1}$ towards an initially stationary proton. Based on its initial trajectory, the electron should have missed the proton by 10 μm if there was no force between them. Now consider only the electrostatic force between the particles. How close together can they get?

A. 0 μm
B. 5 μm
C. 10 μm
D. 15 μm
E. 20 μm

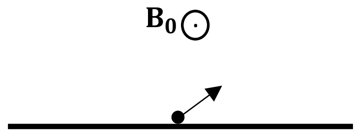
39. An electron initially moving straight up, moves in an almost **circular** path in a uniform magnetic field $\mathbf{B_0}$, the direction of the magnetic field is out of the paper. There is also a uniform **downwards** gravitational field $\mathbf{g_0}$. The next time when the electron is moving straight up again, it will be displaced slightly _____. (Hint: think carefully about the speed of the electron at various parts of its orbit and how that changes its orbit)

A. right
B. left
C. up
D. down
E. out of the paper



40. An electron is emitted from the surface of a metal plate at an angle of 45 degrees from the surface. The electron's initial **kinetic energy** is 2.4×10^{-17} J. A uniform magnetic field $\mathbf{B_0} = 1$ T is applied in the direction as shown in the figure. How far is the electron when it is **furthest** from the plate from which it was emitted? Assume no other forces other than that due to the magnetic field.

A. 0.012 mm
B. 0.033 mm
C. 0.041 mm
D. 0.071 mm
E. No limit. It just keeps going.



41. **Two** identical Light Emitting Diodes (LED) are connected in **series** with a resistor, R, and a 6.0V ideal battery. The potential difference across the LED and the current through the LED may be modelled by the equation $I_{LED} = (V_{LED} - V_{th})/R_{LED}$ for $V_{LED} \geq Vth$, $I_{LED} = 0$ for $V_{LED} < V_{th}$ where $V_{th} = 2.0V$ and $R_{LED} = 10\ \Omega$. Using the model, calculate the value of the resistance R if the current has to be kept at 20mA.

A. 10 Ω
B. 20 Ω
C. 40 Ω
D. 60 Ω
E. 80 Ω

42. **Two** identical LED light bulbs are rated as 12W, 100-240V. That is, the electronics within the bulb provides fixed 12W of electrical power to the light emitting diodes in the bulb as long as the AC power supply can provide an RMS voltage anything between 100V to 240V. Assume the electronic circuit is 100% efficient. What is the current when the two bulbs are connected in **series** to 240V?

A. 0.012 A
B. 0.025 A
C. 0.050 A
D. 0.10 A
E. 0.20 A

43. A battery of emf 1.80 V has an internal resistance of 0.75 Ω. When a wire with circular cross-section of 1.5 cm in diameter and 125 m long is connected across the terminals of this battery, the current is 0.25 A. What is the resistivity of the material from which the wire is made?

A. $7.60 \times 10^{-6}\ \Omega\text{m}$
B. $9.80 \times 10^{-6}\ \Omega\text{m}$
C. $8.20 \times 10^{-6}\ \Omega\text{m}$
D. $9.10 \times 10^{-6}\ \Omega\text{m}$
E. $4.20 \times 10^{-6}\ \Omega\text{m}$

44. When a capacitor C is connected directly to an ideal AC voltage source with an amplitude of 1.0V , the AC current has an amplitude 1.0 A. When an inductor L is connected directly to the same source, the AC current has the same amplitude of 1.0 A. When a resistor R is connected directly to the same source, the AC current has the same amplitude. When all three components are connected in series with the ideal AC voltage source with an amplitude of 1.0V, the AC currents amplitude is _____. Assume that the AC frequency is constant.

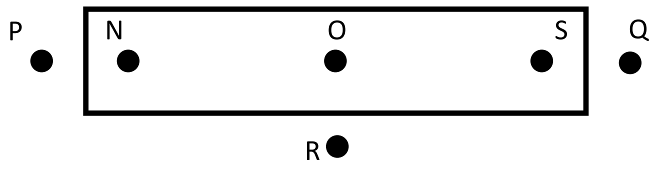
A. 0.33 A
B. 0.58 A
C. 1.0 A
D. 1.7 A
E. 3.0 A

45. In hydrodynamics, mass flow rate is the rate of flow of mass and can be positive of negative but has no direction. In electricity, the rate of flow of charge is electric current. In a circuit, a 1V battery is connected to a 1 Ω resistor so that there is an electric current. The electric current is __________________ flowing through the positive terminal of the battery and ___________ through the other terminal and _________________ through the whole surface of the battery including both terminals.

A. 1 A , −1 A , 0 A
B. 1 A, 1 A , 1 A
C. 1 A , 1 A , 0 A .
D. 1 A , 1 A , 2 A
E. 1 A , 1A , it doesn't make sense to talk about the current

46. In the diagram, the magnitude of the magnetic field at various points around and within a bar magnet are labelled N,O,P,Q,R,S. The north pole is on the left and the south pole is on the right. All points are on the same plane which divides the magnet into two equal halves (one half above and the other half below the paper so that points N, O, and S are inside the magnet). The perpendicular distance between each point and the nearest surface of the magnet is the same. Which ranking is correct?

A. P>Q>O>R
B. N=S>R>O
C. O>N=S>P
D. N=S>R>O
E. P=Q>R>O

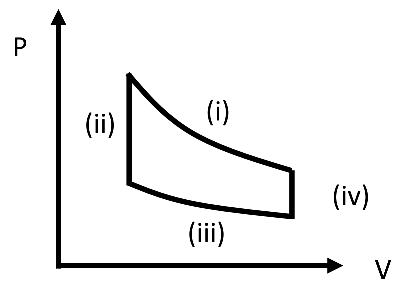


47. A thermoelectric heater operates by the Peltier effect. A model of a thermoelectric heater device makes use of a combination of only the three following components: 1) an ideal heat pump, which pumps heat from the cold side to the hot side using electricity as the "work"; 2) a resistance in series with the heat pump; 3) a heat conductor in parallel to the heat pump which allows heat to flow from the cold side to the hot side. For a device operated at V=12 V, Area $A = 4.0\text{ cm} \times 4.0\text{ cm}$ thickness $d = 5.0\text{ mm}$ thermal conductivity $k = 2.0\text{ Wm}^{-1}\text{K}^{-1}$ and electrical resistance $R = 2\ \Omega$. If the hot side has to be at $80°\text{C}$, this model predicts that the maximum positive temperature difference, which can be achieved (i.e. $T_{hot} - T_{cold}$) is around _________. (Hint: The maximum power supplied to the heat pump is limited by V and R. Coefficient of performance for heating is $COP_{heating} = \frac{T_{hot}}{T_{hot} - T_{cold}}$)

A. 10 K
B. 20 K
C. 40 K
D. 80 K
E. 160 K

48. The first law of thermodynamics states that the change in internal energy is the heat _________________.
A. added to the system minus the work done by the system.
B. added to the system plus the work done by the system.
C. added to the system minus the work done on the system.
D. released by the system plus the work done on the system.
E. heat released by the system minus the work done by the system.

49. A **refrigerator** uses a **fixed quantity** of an **ideal gas** and undergoes a cycle, as shown in the diagram below. The parts of the cycle are labelled as: (i) **isothermal** (same temperature) process (ii) **isochoric** (same volume) process (iii) **isothermal** process and (iv) **isochoric** process. Which part(s) of the cycle has/have heat flowing **out of** the gas?



A. (i) only.
B. (ii) only.
C. (i) and (iii).
D. (iii) and (iv).
E. (i) and (ii) .

50. Suppose that you own an unmarked gold bar. When you measured its mass, the scale that you used gives a reading of 0.998 kg. The uncertainty of the scale is given as ± **0.005 kg**. However, the very next day, you found that there are 3 unmarked gold bars in the place where you had left your own gold bar. When you measured their mass **using the same scale**, you found that:

gold bar a = 0.991 kg
gold bar b = 1.002 kg
gold bar c = 1.005 kg

Which of these gold bars **could possibly** be your original unmarked gold bar?
A. None of them
B. Gold bar b only
C. Either gold bar a or gold bar b only
D. Either gold bar b or gold bar c only
E. Any of them