NTU PHYSICS CHALLENGE

(ADVANCED LEVEL)

22 July 2023 9.30 – 11.30 am

Instructions to participants:

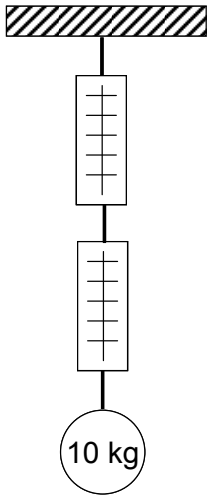
1. The test comprises 60 multiple choice questions on 24 printed pages (including the front and back pages).
2. All questions carry equal marks.
3. Use black lead 2B pencils to shade in the answer sheet provided. Ensure that the circles are filled in completely. Any erasure must be done cleanly and make no stray mark on the answer sheet.
4. Use $g = 10$ m/s^2; $c = 3 \times 10^8$ m/s; $h = 6.63 \times 10^{-34}$ J·s; charge of an electron $e = 1.6 \times 10^{-19}$ C.

Mechanics

1. Consider what happens when you jump up in the air. Which of the following is the most accurate statement?

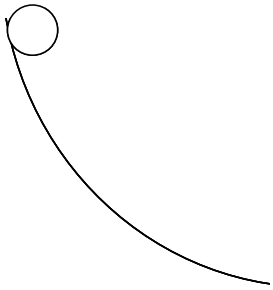
   A. It is the upward force exerted by the ground that pushes you up, but this force can never exceed your weight.
   B. You are able to spring up because the earth exerts a force upward on you which is stronger than the downward force you exert on the earth.
   C. Since the ground is stationary, it cannot exert the upward force necessary to propel you into the air. Instead, it is the internal forces of your muscles acting on your body itself which propels the body into the air.
   D. When you push down on the earth with a force greater than your weight, the earth will push back with the same magnitude force and thus propel you into the air.
   E. When you jump up the earth exerts a force F_1 on you and you exert a force F_2 on the earth. You go up because $F_1 > F_2$, and this is so because F_1 is to F_2 as the earth's mass is to your mass.

2. A 10 kg mass is suspended from two spring scales, each of which has negligible weight as shown below. Thus,



   A. each scale will read 5 kg.
   B. the top scale will read zero, the lower scale will read 10 kg.
   C. the lower scale will read zero, the top scale will read 10 kg.
   D. each scale will show a reading between one and 10 kg, such that the sum of the two is 10 kg. However, exact readings cannot be determined without more information.
   E. none of these is true.

3. As the ball here rolls down the hill as shown in the figure below



A. its speed increases and its acceleration decreases.
B. its speed decreases and its acceleration increases.
C. both its speed and acceleration increase.
D. both speed and acceleration remain constant.
E. both its speed and acceleration decrease.

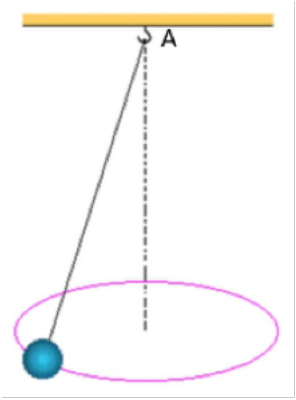
4. A bunch of bananas hangs from the end of a rope that passes over a light, frictionless pulley. A monkey of mass equal to the mass of the bananas hangs from the other end of the rope. The monkey and the bananas are initially balanced and at rest. Now the monkey starts to climb up the rope, moving away from the ground with speed v. What happens to the bananas?

A. They move downward at speed v.
B. They remain stationary.
C. They move up at speed $\frac{1}{2}v$.
D. They move up at speed v.
E. They move up at speed $2v$.

5. A hydroelectric dam has a water height of 50 metres (as measured from the bottom of the dam where water is let out). What is the rate at which water is let out to produce 50MW of electrical power? You should assume an energy conversion efficiency of the dam (from mechanical to electrical) to be 30%, and the density of water as 997 kg/m^3. Assume that the dam is large enough so that the water height does not substantially change during power generation, and you may round off to the nearest whole number.

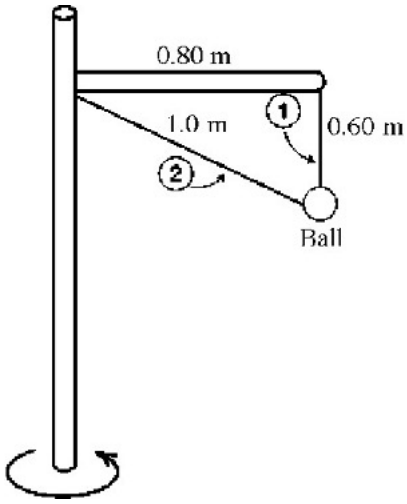
A. 34 m^3/s
B. 102 m^3/s
C. 51 m^3/s
D. 341 m^3/s
E. 33433 m^3/s

6. An object of mass 3.5 kg is attached to one end of a light inextensible string of length 0.5 m as shown in the figure below. The other end of the string is attached to a fixed point. The object moves with constant angular speed in a horizontal circle of radius 0.4 m. The centre of the circle is vertically below the fixed point. Calculate the angular speed of the object.



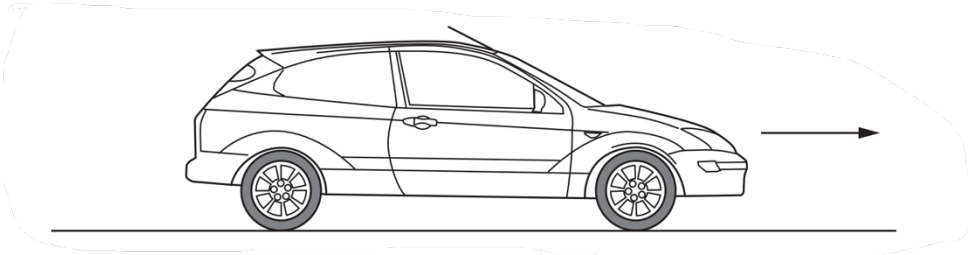
A. 4.43 rad/s
B. 4.95 rad/s
C. 5.11 rad/s
D. 3.84 rad/s
E. 5.72 rad/s

7. A ball of mass 5.0 kg is suspended by two wires from a horizontal arm that is attached to a vertical shaft as shown below. The shaft is in uniform rotation about its axis. The rate of rotation is adjusted until the tensions in the two wires are equal. At that speed, the radial acceleration of the ball is



A. 3.3 m/s^2.
B. 4.9 m/s^2.
C. 6.9 m/s^2.
D. 7.9 m/s^2.
E. 9.9 m/s^2.

8. A car with front-wheel drive accelerates in the direction shown.



Which diagram best shows the direction of the total force exerted by the road on the front wheels?

A. 

B. 

C. 

D. 

E. no force exerted

9. A child drinks a liquid of density ρ through a vertical straw. Atmospheric pressure is p_0 and the child is capable of lowering the pressure at the top of the straw by 10%. The acceleration of free fall is g. What is the maximum length of straw that would enable the child to drink the liquid?

A. $\frac{p_0}{10\rho g}$

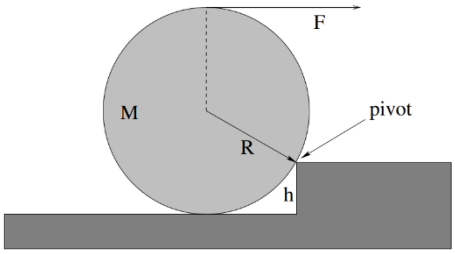
B. $\frac{9p_0}{10\rho g}$

C. $\frac{p_0}{\rho g}$

D. $\frac{10p_0}{\rho g}$

E. $\frac{9p_0}{\rho g}$

10. What is the minimum force F that must be applied to cause the cylinder to barely lift up off of the bottom step and rotate up around the corner of the next one? Assume that the cylinder does not slip on the corner of the next step.



A. $\frac{Mg\sqrt{R^2-h^2}}{R+h} + Mg$

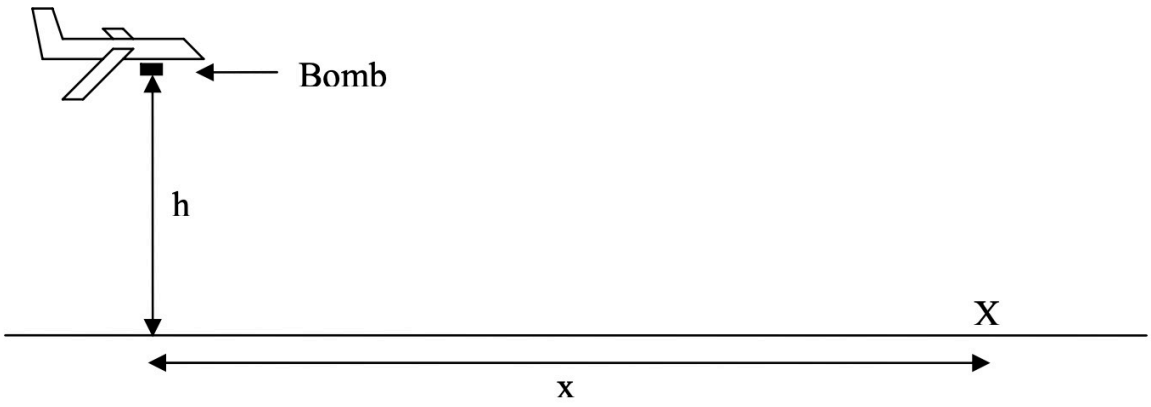
B. $\frac{Mg\sqrt{R^2-h^2}}{R+h}$

C. $\frac{Mg\sqrt{R^2-(R-h)^2}}{2R-h} + Mg$

D. $\frac{Mg\sqrt{R^2-(R-h)^2}}{2R-h}$

E. $\frac{Mg\sqrt{R^2-(R-h)^2}}{2R-h} - Mg$

11. A bomber that is flying at a height h and a velocity v plans to drop a bomb on target X. At what ground distance x from the target must he release the bomb in order for it to hit the target? (We ignore air resistance).



A. $x = 0$

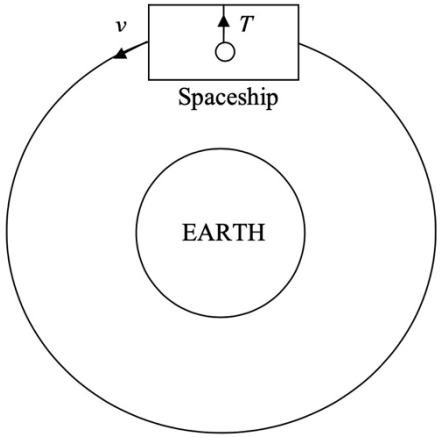
B. $x = v\left(\frac{2h}{g}\right)^{\frac{1}{2}}$

C. $x = \frac{v^2}{2g}$

D. $x = h$

E. $x = v\left(\frac{h}{g}\right)^2$

12. A spaceship, with its booster turned off, is coasting at a uniform speed v around Earth. What is the tension T of the string of a simple pendulum that is at rest and is hung on the ceiling of the spaceship as shown below? Assume that $R_S = R_P$.



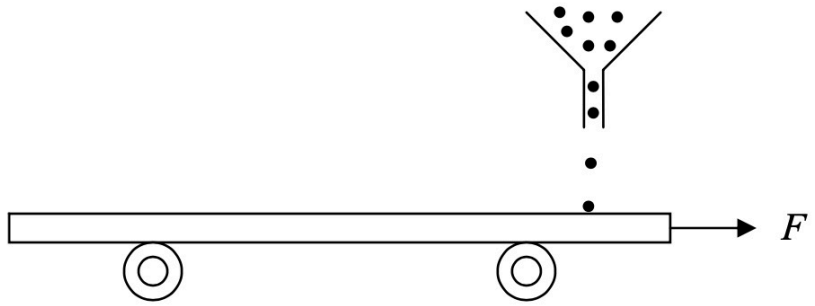
M_E - Mass of Earth
M_S - Mass of Spaceship
M_p - Mass of pendulum
R_S - Distance from spaceship to the center of Earth
R_p - Distance from pendulum to the center of Earth

A. $T = \frac{GM_EM_P}{{R_P}^2}$
B. $T = \frac{GM_EM_S}{{R_S}^2}$
C. $T = \frac{M_Pv^2}{R_P}$
D. $T = \frac{M_Sv^2}{R_S}$
E. $T = 0$

13. Two point objects A and B are separated by a finite distance R and act on each other through their gravitational field. If the mass of A is doubled and the distance R is tripled, what happens to their gravitational potential?

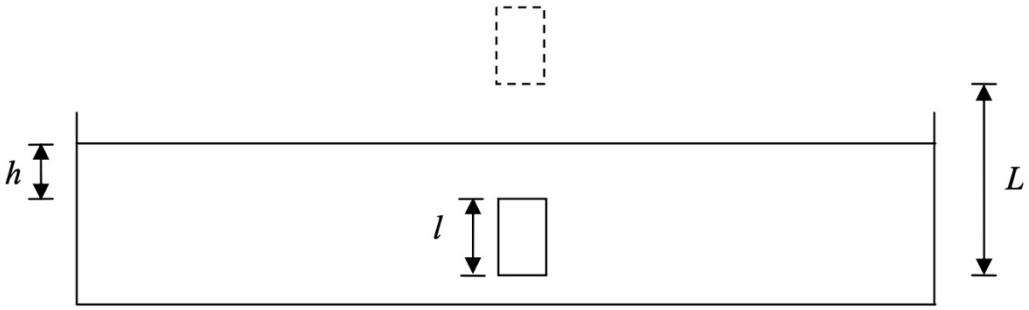
A. Their gravitational potential increases.
B. Their gravitational potential remains unchanged.
C. Their gravitational potential decreases.
D. The direction of their gravitational potential changes.
E. Their gravitational potential cannot be determined as it depends on the path taken for the distance R to change.

14. A flatcar of mass m moves towards the right from rest due to a constant horizontal force F. At the same time, sand spills on the flatcar from a stationary hopper at a constant rate of μ kg/s. What is the dependence of the velocity v of the flatcar with respect to time t, assuming that friction is negligibly small?



A. $v = \frac{Ft}{m+\mu}$
B. $v = \frac{F}{\mu}\ln\left(\frac{m+\mu t}{m}\right)$
C. $v = \frac{2Ft}{2m+\mu t}$
D. $v = \frac{Ft}{m+\mu t}$
E. $v = \frac{Ft}{m}$

15. A uniform body of mass M and volume V (with length l) is immersed in a fluid of density ρ at a depth h within a very wide container as shown in the figure below. What is the work done required to raise the body up a distance L? Assume that the volume of water in the container is much larger than V.



A. MgL
B. $MgL - \rho Vgh$
C. $MgL - \rho Vgl$
D. $MgL - \rho Vg(h + l)$
E. $MgL - \rho Vg(h + \frac{l}{2})$

Thermodynamics and Matter

16. Which of the following statements is **not** true about the molecules of an ideal gas?

A. They are treated as point particles.
B. They have zero mass.
C. They experience no force between themselves except during collisions.
D. They have zero intermolecular potential energy.
E. The temperature of the gas is a measure of their average kinetic energy.

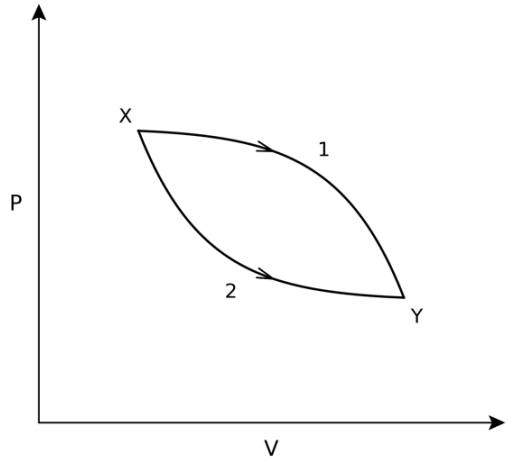
17. When a small mass of air in the atmosphere is heated, which of the following statements is most accurate?

A. The heated air does not rise or sink. The heat energy decreases the temperature of the air mass.
B. The heated air rises as its density decreases. The heat energy increases the temperature of the air mass.
C. The heated air rises as its density decreases, and its volume expands as it rises. The heat energy both increases the temperature of the air mass and performs work to expand it.
D. The heated air sinks as its density increases. The heat energy increases the temperature of the air mass.
E. The heated air sinks as its density increases, and its volume reduces as it sinks. The heat increases the temperature of the air mass and leads to work being done on the air.

18. Approximately 2 GW of cooling power is required from a cold source to cool down a power plant that produces 1 GW of electricity. To do so, one would like to use a river with a flow rate of 500 m^3/s. Note that 4187 J of heat is needed to increase the temperature of 1 kg of water by 1 °C. Which one of the following statements below is correct?

A. The river's water temperature remains constant.
B. The temperature of the water in the river increases by about 0.5 °C.
C. The temperature of the water in the river increases by about 1 °C.
D. The temperature of the water in the river increases by about 5 °C.
E. The numerical values provided are unreasonable because they imply that the temperature of the water in the river increases to boiling point.

19. The figure below shows the pressure (P) vs volume (V) diagram of an ideal gas undergoing thermodynamic transitions. What is the relation between the change in internal energy (U) and the heat supplied (Q) during the process 1 and 2 as the system transit from state X to state Y? Note that both paths start at X and end at Y.



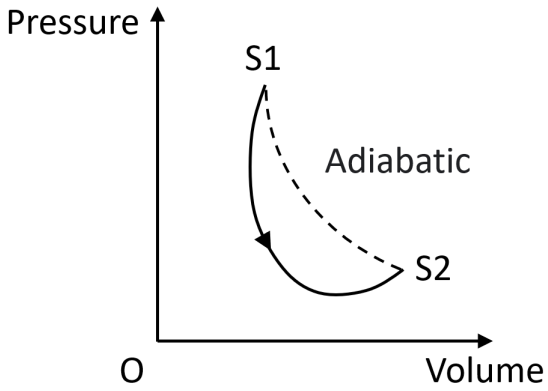
A. $U_1 > U_2$, $Q_1 > Q_2$
B. $U_1 < U_2$, $Q_1 > Q_2$
C. $U_1 = U_2$, $Q_1 = Q_2$
D. $U_1 = U_2$, $Q_1 < Q_2$
E. $U_1 = U_2$, $Q_1 > Q_2$

20. The triple point of water occurs at 0.01°C and 0.006 atm. The melting point of ice occurs at 0°C and 1 atm. Which of the following statements can be deduced from these facts?

(i) Raising the surrounding pressure lowers the melting point of ice.
(ii) Water occupies a smaller volume than ice at the same temperature and pressure.
(iii) We can use the triple point of water to calibrate the absolute temperature scale.

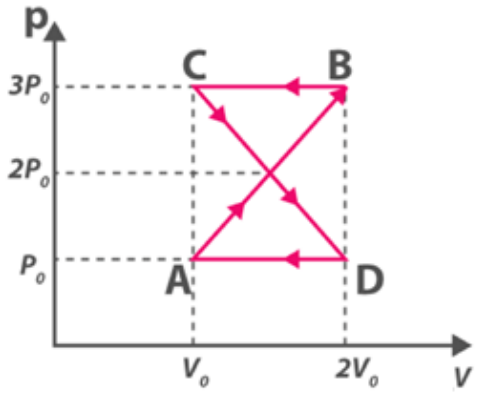
A. (i) only
B. (ii) only
C. (iii) only
D. (i) and (ii)
E. (ii) and (iii)

21. The solid curve in the figure below shows a thermodynamic process in an ideal gas, which connects two states S_1 and S_2 (from S_1 to S_2). S_1 and S_2 are on the same adiabatic curve shown by the dashed curve. By definition no heat is transferred during an adiabatic process. The internal energy of the gas is U_1 at S_1 and U_2 at S_2. During the process shown by the arrowed line, the net heat transferred into the system is Q. Which of the following options is correct?



A. $U_2 < U_1, Q = 0$
B. $U_2 < U_1, Q < 0$
C. $U_2 > U_1, Q < 0$
D. $U_2 < U_1, Q > 0$
E. $U_2 > U_1, Q > 0$

22. ABCDA is a cyclic thermodynamic process, shown in the figure below. What is the work done by the system in one complete cycle ABCDA?



A. 0
B. $P_0V_0/2$
C. $-P_0V_0$
D. $2\,P_0V_0$
E. $-3\,P_0V_0$

23. An ideal gas is confined in a container with flexible walls that always keeps the pressure inside constant. Suppose the gas shrinks very slowly to half its original volume. Which of the following statements is definitely false?

A. The walls of the container conduct heat and it is cooler outside.
B. The walls of the container are semi-permeable, and the gas is diffusing out of the container through the walls.
C. The walls of the container are impermeable, and the average kinetic energy of the gas molecules has fallen.
D. The walls of the container are impermeable and are made of a perfect insulator to heat.
E. The walls of the container are semi-permeable and conduct heat.

24. Bubbles in a boiling pot get larger as they rise to the surface. Which of the following can account for this?

(i) The temperature at the surface is higher than at the bottom of the pot.
(ii) The external pressure on the bubbles is less at the surface.
(iii) Additional water vaporises into the bubbles.

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

Waves and Oscillations

25. A cylinder of radius R, length h, and density ρ_0 floats upright in a fluid of density ρ_1. It is given a small vertical displacement, and undergoes undamped harmonic motion with angular frequency ω. Which of the following relations is correct?

A. $\omega^2 = \frac{\rho_0 g}{\rho_1 h}$
B. $\omega^2 = \frac{\rho_1 g}{\rho_0 h}$
C. $\omega^2 = \frac{\rho_0 h}{\rho_1 g}$
D. $\omega^2 = \frac{\rho_1 h}{\rho_0 g}$
E. $\omega^2 = 2\frac{\rho_1 h}{\rho_0 g}$

26. The Doppler effect manifests as:

A. The variation of the observed brightness of stars with distance from the Earth.
B. The change in temperature of a gas as it expands and contracts.
C. The change in pitch of an ambulance's siren as it passes an observer.
D. The color gradient of a rainbow formed by sunlight passing through water droplets.
E. More than one of the above options.

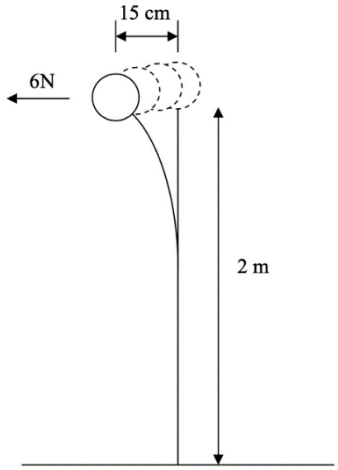
27. A continuous sound wave of fixed frequency travels through two non-dissipative (or lossless) media with different densities (e.g., water and air). At steady state, which of the following is correct?

A. The wave speed is the same in both media.
B. The wavelength is the same in both media.
C. The ratio of wave speed to wavelength is the same in both media.
D. The energy fluxes are the same in both media.
E. More than one of the above options.

28. Why are X-rays so useful in medicine for imaging bones and other tissues of the body?

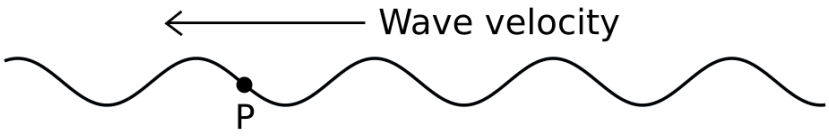
A. X-rays do not interact strongly with matter compared to other forms of radiation, so they can easily penetrate the body.
B. X-ray wavelengths are longer than the characteristic length scales of tissues in the body, so they can easily penetrate the body.
C. X-rays have very short wavelengths, so they can produce super-high-resolution images at nanometer-scale resolutions.
D. X-rays are non-ionising radiation, so they do not damage the body as much other other kinds of radiation.
E. More than one of the above options.

29. A very light steel rod of length 2 m is clamped at its lower end, and a 2 kg ball is fastened to its top. A horizontal force of 6 N is required to displace the ball 15 cm to one side, as shown below. Upon release, the system undergoes simple harmonic motion. What is the period of oscillation?



A. 0.31 s
B. 0.99 s
C. 1.4 s
D. 5.1 s
E. None of the above

30. The figure below shows a rope carrying a transverse left-moving wave. In which direction is the point P on the rope moving?



A. Up
B. Down
C. Left
D. Right
E. The point P remains stationary.

Electricity and Magnetism

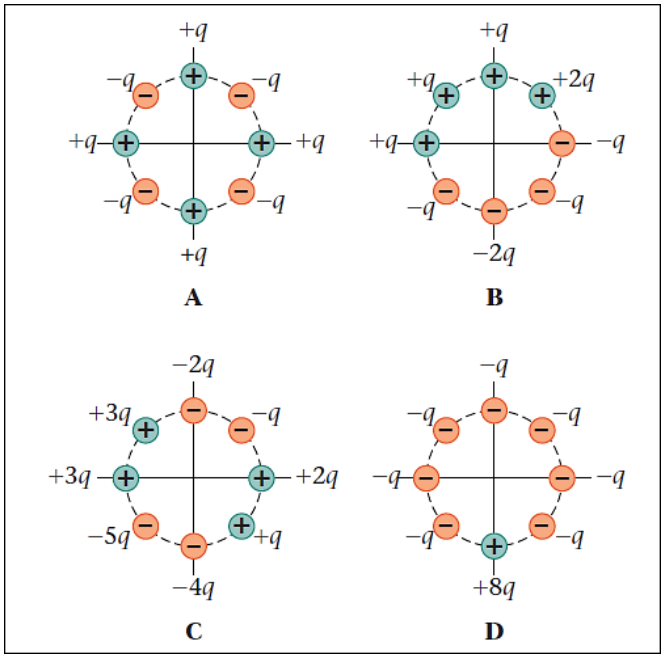
31. A spherical metal shell is uniformly charged. At which point(s) is the electric field the greatest?

A. Inside the metal shell.
B. In the hollow region.
C. On the surface of the shell.
D. Far away from the shell.
E. The electric field is the same everywhere.

32. A charged conductor is in electrostatic equilibrium. Which of the following is true about the charge distribution?

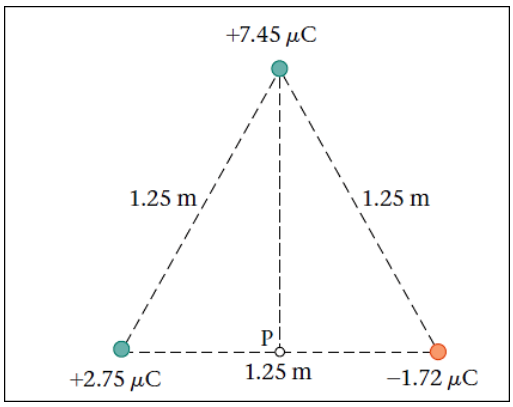
A. The charge is uniformly distributed throughout the conductor.
B. The charge is concentrated at the center of the conductor.
C. The charge resides entirely on the surface of the conductor.
D. The charge is distributed randomly throughout the conductor.
E. None of the above.

33. Four different arrangements of point charges are shown in the figure below. In each case, the charges are at the same distance from the origin. Taking the electric potential at infinity to be zero, which arrangement(s) has the smallest electric potential at the origin?



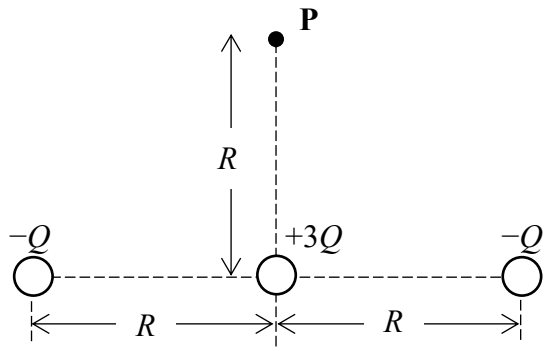
A. Arrangement A
B. Arrangement B
C. Arrangement C
D. Arrangement D
E. All arrangements have the same electric potential

34. Suppose the three charges shown in the figure below are held in place. A fourth charge, with a charge of +4.82 μC and a mass of 2.33 g, is released from rest at Point P (located halfway between charges +2.75 μC and -1.72 μC) . What is the speed of the fourth charge when it has moved infinitely far away from the other three charges?



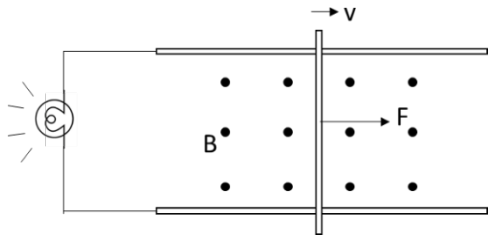
A. 17.8 m/s
B. 22.8 m/s
C. 178 m/s
D. 228 m/s
E. 316 m/s

35. Three point charges $-Q$, $+3Q$, and $-Q$ are arranged along a horizontal straight line as shown in the figure below. What is the electric potential at the point **P**?



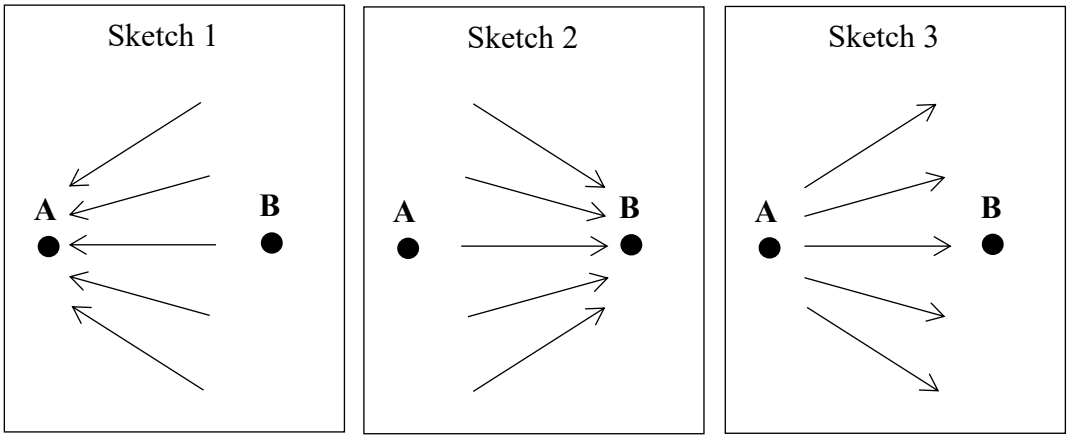
A. $+kQ/R$
B. $-2kQ/R$
C. $-1.6kQ/R$
D. $+1.6kQ/R$
E. $+4.4kQ/R$

36. Someone is pulling a metal bar with constant force $\vec{F}$, as shown in the following figure. The metal bar is sliding on two metal tracks with no friction. A uniform and constant magnetic field $\vec{B}$ is applied in the direction perpendicular to the paper. Note that the bar and tracks form a closed circuit that is connected to a light bulb on the left hand side. Due to magnetic induction, there is a current induced in the circuit, and the metal bar is also subject to a magnetic force. It is known that the metal bar is in mechanical equilibrium with zero net force, thus moving with constant velocity $\vec{v}$. Given that the light bulb's current power is $P = \vec{F}.\vec{v}$, what is the power due to the magnetic force acting on the metal bar?



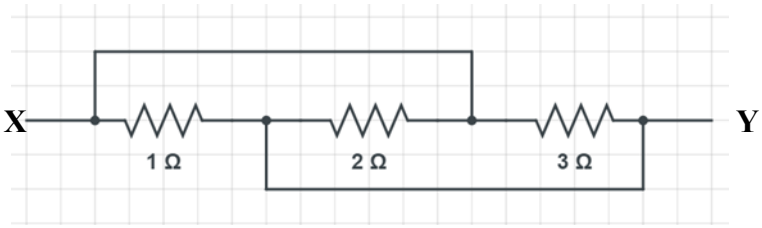
A. 0
B. $P/2$
C. P
D. $3P/2$
E. $2P$

37. Which of the three sketches, or combination of sketches, of electric field lines, 1, 2, and 3, show a situation where the electric potential is larger at point B than at point A?



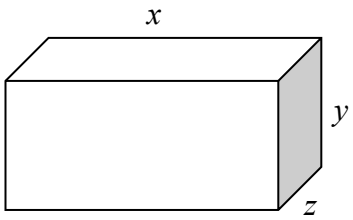
A. 1
B. 2
C. 3
D. 1 and 2
E. 2 and 3

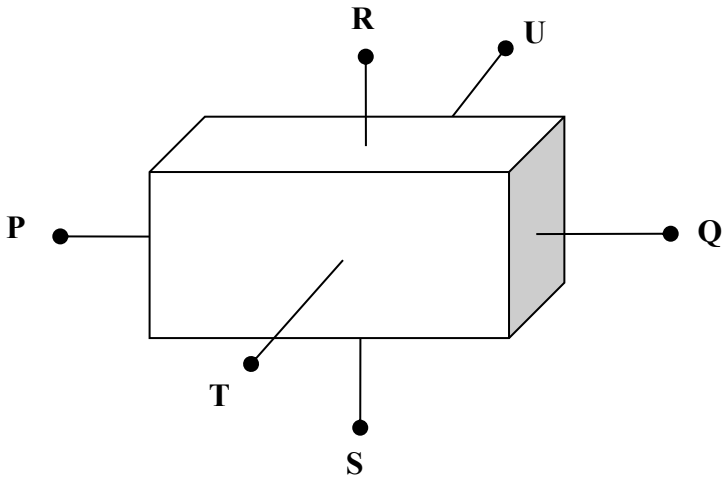
38. Three resistors are arranged as shown in the figure below using connecting wires of negligible resistance. What is the equivalent resistance between points **X** and **Y**?



A. 0.5 Ω
B. 1.8 Ω
C. 2.2 Ω
D. 3.6 Ω
E. 6.0 Ω

39. A metal strip with sides of length x, y and z are as shown in the figure below, where $x > y > z$. If a potential difference was applied separately across terminals PQ, RS and TU, which of the following is true of the current flowing through the different terminals? *Figure not drawn to scale*.



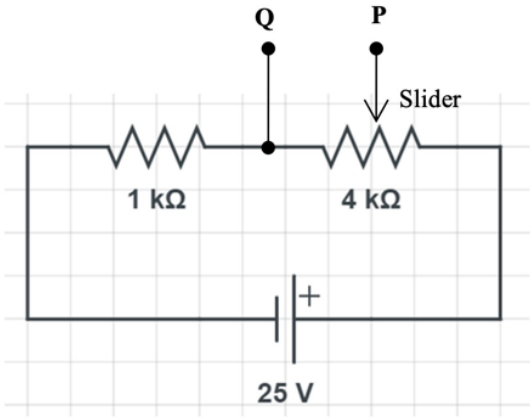


	Highest	Lowest
A.	PQ	RS
B.	RS	TU
C.	TU	PQ
D.	PQ	TU
E.	TU	RS

40. When a dc current I flows through a resistor R, the power produced is P. An alternating current produces power ¼P in the same resistor. What is the peak value of the alternating current?

A. $\frac{1}{4}I$
B. $\frac{1}{\sqrt{2}}I$
C. $\sqrt{2}I$
D. I
E. $2I$

41. A potential divider circuit consists of two resistors and a sliding contact is as shown in the figure below. The potential difference between terminals **P** and **Q** varies as the position of the slider is adjusted. What is the minimum and maximum potential difference between terminals **P** and **Q** as the position of the slider varies?



	Minimum	Maximum
A.	0 V	20 mV
B.	5 mV	25 mV
C.	0 V	20 V
D.	0 V	25 V
E.	5 V	25 V

42. Eight identical drops of mercury are each charged to an electric potential of 4 V. If the drops are now combined to form one large drop of mercury, its electric potential will be

A. 4 V.
B. 8 V.
C. 16 V.
D. 32 V.
E. $8\sqrt{2}$ V.

43. If the electric field is zero within some region of space,

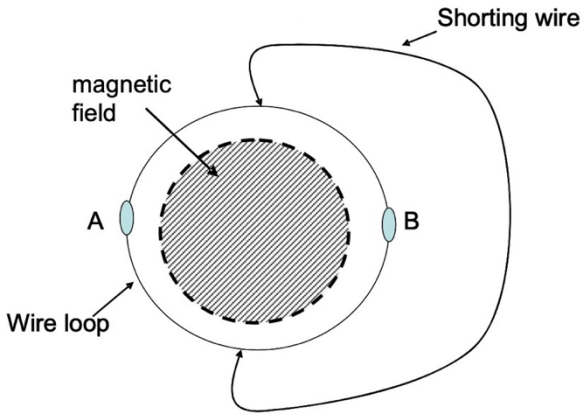
(i) the electric potential must be zero within that region.
(ii) the electric potential must be a constant value within that region.
(iii) no electric charges must be present in the surrounding region.

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

44. A real battery can be considered to be an ideal battery of potential ε in series with an internal resistance r. If the battery is connected to a single "load" resistance R, which of the following values of R gives the highest power dissipated by the load?

A. $R = r/10$
B. $R = r/2$
C. $R = r/\sqrt{2}$
D. $R = r$
E. $R = 10r$

45. A magnetic field is generated within the shaded area such that its direction points into the page and its magnitude increases with time. This induces an emf in a conducting wire loop which lights two identical bulbs A and B connected in series along the wire. Now two points diametrically opposed on the wire loop are shorted with another wire lying to the right of bulb B in the plane of the page. After the shorting wire is inserted, which of the following is true?



A. Both bulbs go out.
B. Bulb A goes out, and bulb B gets brighter.
C. Bulb B goes out, and bulb A gets brighter.
D. Both bulbs remain bright.
E. The lighting of the bulbs depends on the direction of the magnetic field.

Modern Physics

46. Two unknown quantities of two different radioactive nuclides are prepared. Initially, the sample with nuclide A has half the activity of the sample with nuclide B. After time *t*, the two samples have the same activity. What is the half life τ_A of nuclide A in relation to the half life τ_B of nuclide B?

A. $\tau_A = \tau_B$
B. $\frac{1}{\tau_A} = \frac{1}{2\tau_B}$
C. It depends on the numbers of nuclides in the two samples.
D. $\frac{1}{\tau_A} = \frac{1}{\tau_B} + \frac{1}{t}$
E. $\frac{1}{\tau_A} = \frac{1}{\tau_B} - \frac{1}{t}$

47. Which of the following statements most accurately describes the photoelectric effect?

A. The emission of light from a light bulb when an electric current passes through it.
B. The scattering of light when it passes through a prism, creating a spectrum of colors.
C. The emission of electrons from a metal surface when light of sufficient frequency shines on it.
D. The bending of light waves as they pass through a medium with different optical densities.
E. The interference pattern observed when light passes through a pair of narrow slits.

48. Two beams are made of monochromatic light. The first one carries 4.0×10^8 photons per second and the photons are red (632.8 nm). The second carries 1.5×10^8 photons per second and the photons are blue (480 nm). Which beam carries the larger power?

A. The red beam
B. The blue beam
C. They carry the same power.
D. It is not possible to say, because the cross sections are not known.
E. It is not possible to say, because the total volume of the beam is not known.

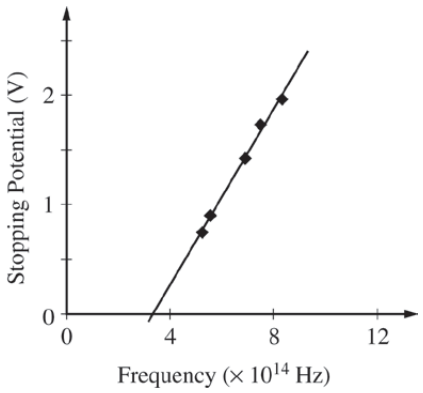
49. Two quantum particles have a de Broglie wavelength of 850 nm. They collide with each other, resulting in a first particle of de Broglie wavelength 840 nm and a second particle. Assuming that the total energy was conserved and all the particles have the same mass, what is the de Broglie wavelength of the second particle?

A. 860.37 nm
B. 488.80 nm
C. 5492 nm
D. 860.24 nm
E. 71400 nm

50. If the mass of a radioactive sample is tripled, the activity of the sample and the decay constant of the sample are respectively

A. Increases by a factor of 3, remains the same.
B. Decreases by a factor of 3, increases by a factor of 3.
C. Decreases by a factor of 3, remains same.
D. Increases by a factor of 3, decreases by factor of 3.
E. Increases by a factor of 3, increases by factor of 3.

51. In an experimental observation of the photoelectric effect of the metal potassium (with work function ϕ), the stopping potential was plotted versus the light frequency, as shown in the figure below. The best straight line was fitted to the experimental points. Which of the following gives the slope of the line of another metal having twice the work function?

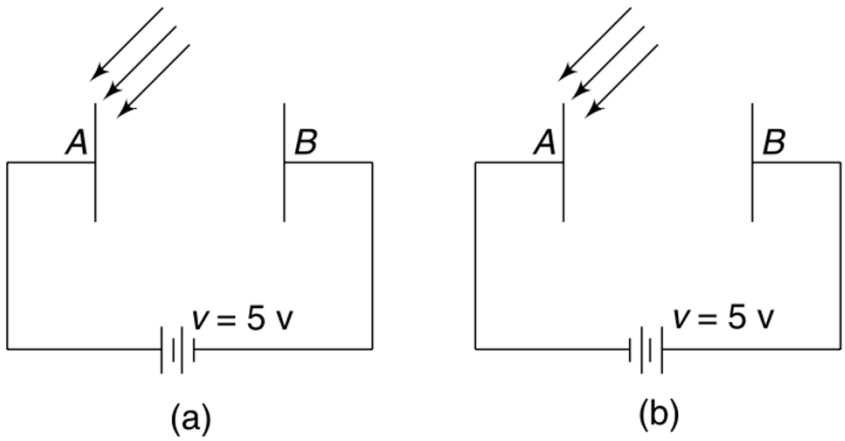


A. $\frac{h}{2\phi}$
B. $\frac{h}{e}$
C. $\frac{e}{h}$
D. $\frac{e}{2\phi}$
E. $\frac{2\phi}{e}$

52. When light of wavelength 450 nm falls on a metal surface, the stopping potential for the emitted electrons is found to be 0.75 V. What is the stopping potential for the photoelectrons if light of wavelength 300 nm falls on the metal surface?

A. 0.50 V
B. 1.13 V
C. 2.00 V
D. 2.13 V
E. 6.28 V

53. In a photoelectric experiment, a monochromatic light is incident on the metal plate A. It was observed that with V = 5 V, the maximum kinetic energy of photoelectrons striking plate B was 1 eV. The polarity of the applied potential difference was as shown in figure (a). With polarity of the applied potential difference reversed (as shown in figure (b)) and frequency of incident light doubled, it was observed that in saturation state, the kinetic energy of electrons striking plate B ranged between 5 eV to 20 eV. Find the work function of metal plate A.



A. 1 eV
B. 2 eV
C. 3 eV
D. 4 eV
E. 5 eV

54. A radioactive nuclide has a half life of 10 s. Which of the following statements are correct?

(i) In a sample, the probability that a nucleus will decay in the next 10 s is 0.5.
(ii) In a sample, the probability that a nucleus which has survived the first 10 s, will decay the next 10 s, is 0.5.
(iii) The probability that a nucleus which has survived the first 10 s, will decay in the next 10 s is 0.25.
(iv) If a sample of the radioactive nuclide has 4 nuclei, two nuclei will decay in the next 10 s.

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

55. The half-life of cobalt-60 is 5.3 years, while that of strontium-90 is 28 years. Suppose that samples of cobalt-60 and strontium-90 are such that they initially have the same activity (number of decays per second). What is true about the initial numbers of cobalt-60 and strontium-90 nuclei in these samples?

A. There are more cobalt-60 than strontium-90 nuclei.
B. It is not possible to compare numbers of nuclei without knowing the masses of the samples.
C. There are equal numbers of cobalt-60 and strontium-90 nuclei.
D. There are more strontium-90 than cobalt-60 nuclei.
E. None of the above are correct.

56. The half-life of radon is 4 days. After how many days will only $1/10^{th}$ of a radon sample be left behind?

A. 13.3 days
B. 26.6 days
C. 39.9 days
D. 53.2 days
E. 66.5 days

57. In a X-ray tube, electrons of high energy E are incident on a target of tungsten. Which of the following three statements are correct?

(i) All the energy is converted to X-rays.
(ii) The maximum X-ray frequency obtained is E/h.
(iii) The X-rays are diffracted by the tungsten metal.

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

58. Two radioactive nucleotides A and B were initially present in the proportion $A : B = 60 : 40$. After three days, this proportion was found to change to $A : B = 30 : 70$. When will be the proportion be $A : B = 10 : 90$?

A. After another 1.3 days
B. After another 3.2 days
C. After another 4.5 days
D. After another 7 days
E. After another 27 days

59. A beam of blue light and a beam of red light carry the same amount of total energy. Which of the following is true?

A. Both beams have the same number of photons.
B. The red beam has more photons.
C. The blue beam has more photons.
D. The blue photons move faster than the red photons.
E. The red photons move faster than the blue photons.

60. We wish to set up the double slit experiment to demonstrate the wave nature of matter according to $\lambda = h/p$, Which of the following conditions is/are needed?

(i) Small mass
(ii) Large velocity
(iii) Large value of h

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

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