Problem 1:

The inter-nuclear distance in Angstrom in the hydrogen molecule is most nearly __?
(A) 0.01 A (B) 0.1 A (C) 1 A (D) 10 A (E) 100 A

Problem 2:

The Maxwell distribution of molecular speeds in a gas is given by

$$n(v) = Av^2 e^{-mv^2/2kT}$$

where A is constant.

The root-mean-square speed is

(A) $\sqrt{\frac{2kT}{m}}$ (C) $\sqrt{\frac{8kT}{m}}$ (E) $\sqrt{2\pi mkT}$

(B) $\sqrt{\frac{3kT}{m}}$ (D) $\frac{3}{2}kT$

Problem 3:

Two events occur at the same place but at different times as measured in an inertial reference frame (IRF) attached to a rocket. The second event occurs t' seconds later than the first. The rocket is moving at a relativistic speed v with respect to a laboratory IRF. What is the distance between the two events, as measured in the laboratory IRF? ($\gamma = 1/\sqrt{1 - v^2/c^2}$)

(A) vt'
(B) vt'γ
(C) vt' / γ
(D) v^2t'/c
(E) vt' / γ^2

Problem 4:

As shown above, a block of mass m is released from rest at a distance h above a vertical massless spring with spring constant k, what is the maximum kinetic energy of the block?

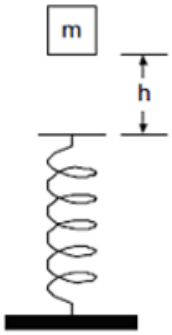
(A) mgh

(B) $mgh + \frac{1}{4}\frac{m^2g^2}{k}$

(C) $mgh + \frac{1}{2}\frac{m^2g^2}{k}$

(D) $mgh + \frac{m^2g^2}{k}$

(E) $2mgh$



Problem 5:

Refer to the following processes involving systems labeled by numbers 1 through 8.

A bar of iron (1) at 300K is brought into thermal contact with a body (2) at 400K, the two being thermally isolated from all other systems.

An ideal gas (3) is compressed reversibly while in contact with a reservoir (4), the two being thermally isolated from all other systems.

A body of water (5) freezes reversibly.

A container of water (6) is stirred and its temperature increases by 1K.

A chemical reaction takes place in an isolated system (7).

A Carnot engine (8) operates in a cycle.

For which of the following systems does the entropy decrease?

(A) 1 (B) 4 (C) 5 (D) 6 (E) 7

Problem 6:

A mass m_1 at the end of a spring executes simple harmonic motion with a period T_1. The period of oscillation of a different mass m_2 on the same spring is

(A) $T_1\sqrt{\frac{m_2}{m_1}}$

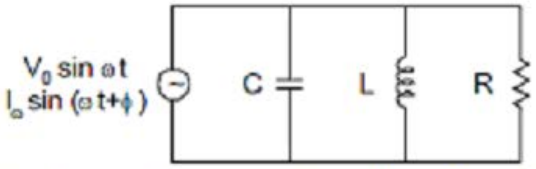
(B) $T_1\sqrt{\frac{m_1}{m_2}}$

(C) T_1

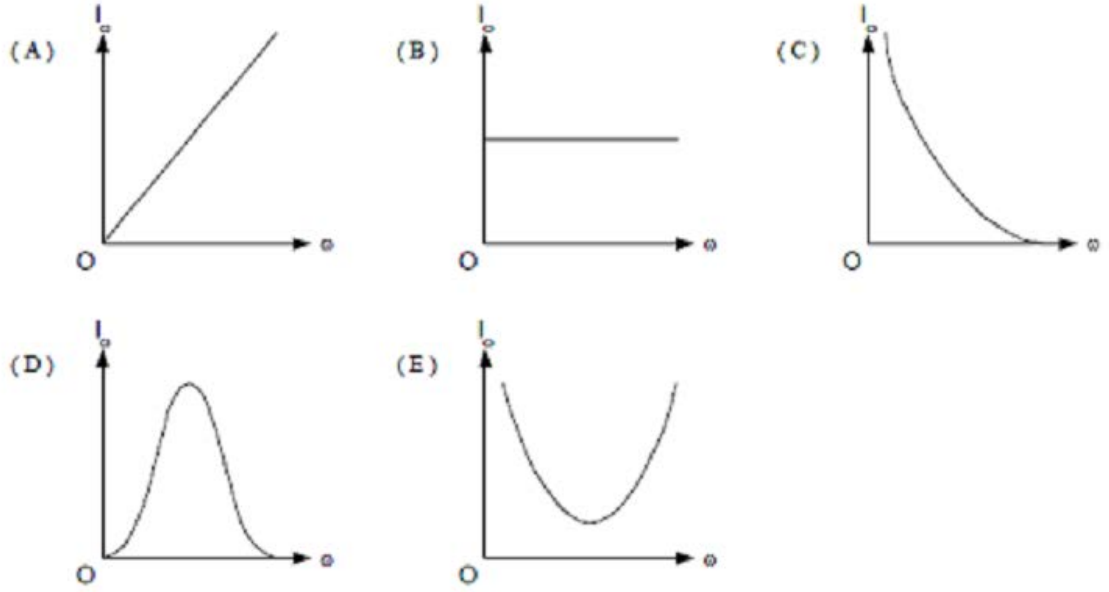
(D) $2\pi\sqrt{\frac{m_1}{m_2}}$

(E) $2\pi\sqrt{\frac{m_2}{m_1}}$

Problem 7:



In the circuit shown above, the maximum generator voltage V_0 is fixed. Which of the following graphs best represents the amplitude I of the current in the generator as a function of the frequency ω?



Problem 8:

Which of the following is NOT an attribute of a typical photomultiplier tube?

(A) It operates by producing an avalanche of ions in a gas.

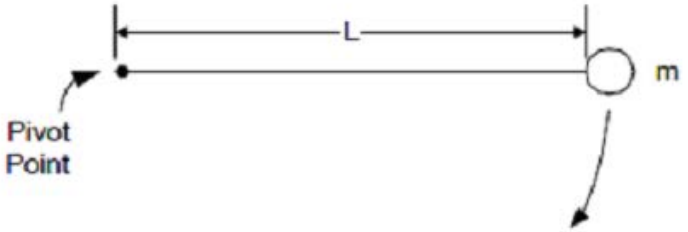
(B) It can produce electrical output pulses less than 10^{-6} second long.

(C) It can produce 10^3 or more electrons per incident photon.

(D) It is affected by a ambient magnetic fields greater than a few gauss.

(E) It detects photoelectrons ejected by light from a photocathode.

Problem 9:



A massless rod of length L is pivoted about a horizontal axis through one end. A small object of mass is attached to the other end. The rod is released from rest in a horizontal position, as shown above, and swings as a pendulum. Assume there is no friction and no air resistance. Which of the following quantities remains constant throughout the motion of the pendulum?

(A) Linear momentum of m
(B) Angular momentum of m relative to the pivot point
(C) Gravitational potential energy
(D) Kinetic energy
(E) None of the above

Problem 10:

The energies of alpha particles emitted by naturally occurring radioactive nuclei typically range from

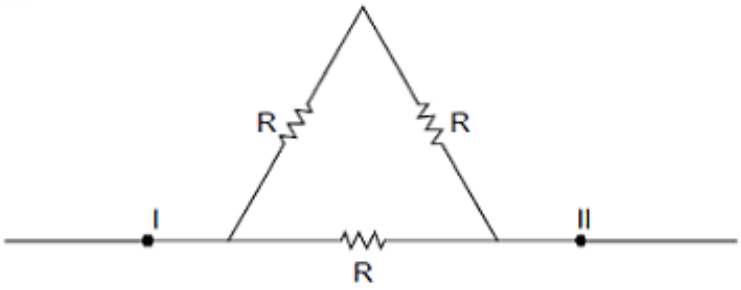
(A) 1 eV to 10 eV
(B) 100 eV to 1keV
(C) 10 keV to 100 keV
(D) 1 MeV to 10 MeV
(E) 100 MeV to 1000 MeV

Problem 11:

For the ^3S state of the Helium atom, the possible values of the total electronic angular momentum are

(A) 0 only
(B) 1 only
(C) 0 and 1 only
(D) 0, 1/2, and 1
(E) 0, 1, and 2

Problem 12:



If V is the potential difference between points I and II in the diagram above and all three resistors have the same resistance R, what is the total current between I and II.

(A) $\frac{V}{3R}$

(B) 3VR

(C) $\frac{2V}{3R}$

(D) $\frac{3VR}{2}$

(E) $\frac{3V}{2R}$

Problem 13:

A golf ball is hit from ground level with an initial velocity v_0 at an angle θ with respect to the ground. If air resistance is negligible and the magnitude of the gravitational acceleration is g, the ball hits the ground at what distance from the point at which it was hit?

(A) $\frac{v_0^2}{g}$

(B) $\frac{v_0^2 \sin\theta}{g}$

(C) $\frac{v_0^2 \cos\theta}{g}$

(D) $\frac{2v_0^2 \tan\theta}{g}$

(E) $\frac{2v_0^2 \sin\theta\cos\theta}{g}$

Problem 14:

An alpha particle and a proton follow the same circular path in a uniform magnetic field. What is the ratio, v_α/v_p, of their nonrelativistic velocities?

(A) 1/4

(B) 1/2

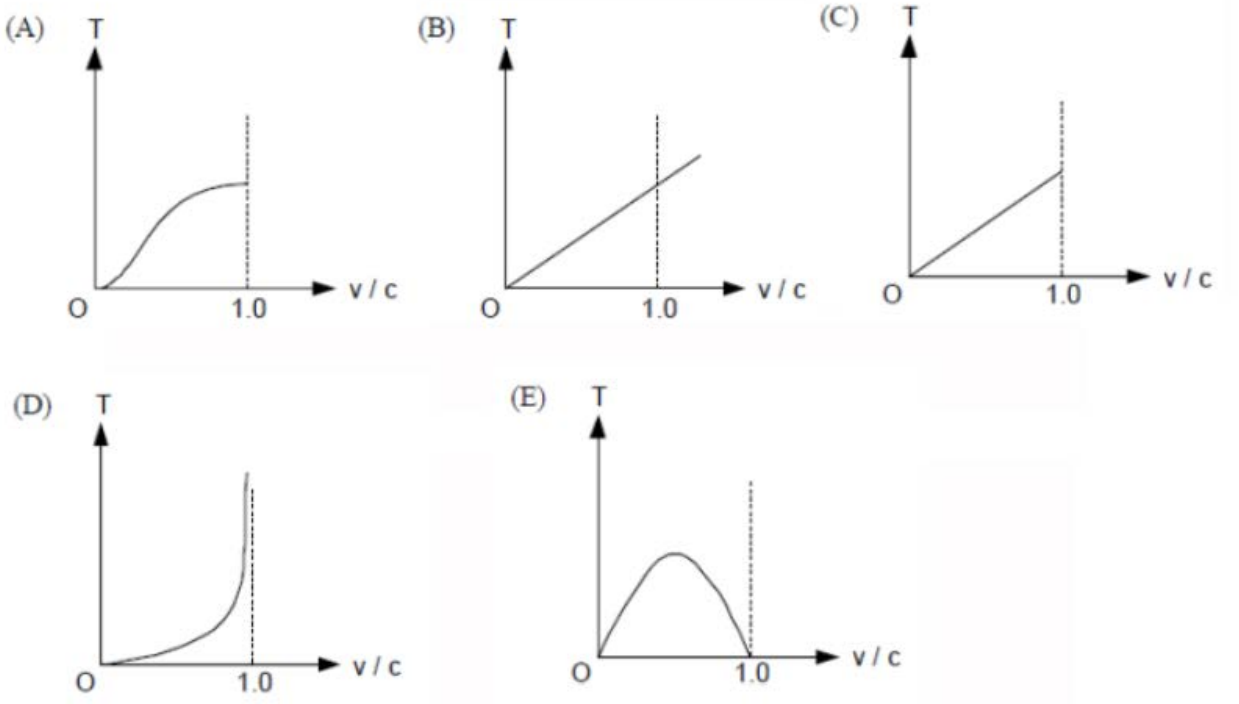
(C) 1

(D) 2

(E) 4

Problem 15:

An electron has speed v. A plot of the kinetic energy T of the electron versus the ratio $\frac{v}{c}$ would look most like which of the following graphs?

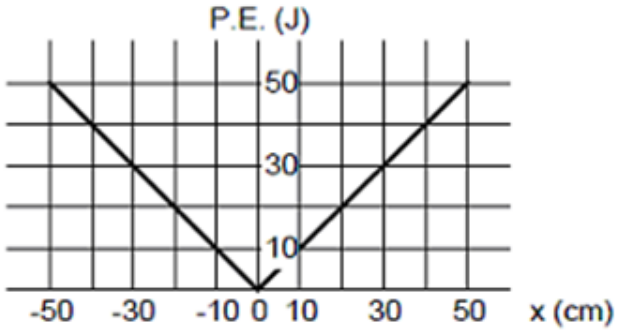


Problem 16:

A hollow metal sphere X of radius 10 centimeters is supported on an insulating stand A second hollow metal sphere Y of radius 2 centimeters is supported on an insulating rod. A hole is made in sphere X just large enough so that sphere Y can be introduced into the interior of X without toughing it. With the two spheres separated, X is given a positive charge of 2000 picocoulombs and Y is given a negative charge of 500 picocoulombs. Y is now introduced into the interior of X so that the two spheres do not touch. After Y is in the interior of X the two spheres are brought into contact and held there. Which of the following statements is true?

(A) There is an electric field inside sphere Y.
(B) The potential of sphere X is equal to that of sphere Y.
(C) The charge redistributes itself so that the charge on sphere X is 5 times the charge on sphere Y.
(D) All of the charge is transferred from sphere X to sphere Y.
(E) No charge is transferred between the two spheres.

Problem 17:



The graph above shows the potential energy (P.E.) in joules of an object of mass m moving horizontally in a conservative one-dimensional force field. If the initial total energy of the object is 30 joules, which of the following statements is NOT correct?

(A) The magnitude of the force acting on the object when it is at $x = -15$ cm is 100 N
(B) The kinetic energy of the object when it is at $x = 5$ cm is 25 J.
(C) The speed of the object is a maximum at $x = 0$.
(D) The motion of the object is periodic in time and has an amplitude of 30 cm.
(E) The period of the motion is independent of the mass of the object.

Problem 18:

Although the sky is blue in the daytime, sunsets are red because

(A) the Sun emits more red light in a forward direction, but more blue light when at a larger angle with the forward direction
(B) the Sun emits more red light than blue light in the evening
(C) the index of refraction of red light in air is greater than that of blue light
(D) there are many ions in the upper atmosphere
(E) red light is less strongly scattered by air molecules than blue light

Problem 19:

The speed of sound in an ideal gas is related to the temperature T of the gas. This speed is proportional to

(A) $T^{\frac{1}{4}}$
(B) $T^{\frac{1}{2}}$
(C) T
(D) $T^{\frac{4}{3}}$
(E) T^{2}

Problem 20:

A machine gun fires bullets of mass 20 grams each at a rate of 1200 bullets per minute. The bullets hit a thick wooden target at a speed of 600 meters per second and are stopped in the target. The average force exerted on the target by the bullets striking it is

(A) 144N
(B) 240N
(C) 14.4×10^3 N
(D) 24.0×10^3 N
(E) 14.4×10^3 N

Problem 21:

Two harmonic transverse waves of the same frequency with displacements at right angles to each other can be represented by the equations

$$y = y_0 \sin(\omega t - kx), \qquad z = z_0 \sin(\omega t - kx + \phi).$$

where y_0 and z_0 are nonzero constants.
The equations represent a plane-polarized wave if ϕ equals

(A) $\sqrt{2}$ (B) $3\pi/2$ (C) $\pi/2$ (D) $\pi/4$ (E) 0

Problem 22:

How many ways can two indistinguishable particles obeying Bose-Einstein statistics be arranged among three states?

(A) 3 (B) 6 (C) 9 (D) 12 (E) 15

Problem 23:

What is the number of degrees of freedom for 6 particles moving freely in one plane?

(A) 6 (B) 8 (C) 10 (D) 12 (E) 18

Problem 24:

The skier shown leaves point A from rest, skies down a frictionless ski jump, leaves the jump at point B, and hits the ground at point C. The height at A and B are h_A and h_B. What is the skier's speed just before hitting the ground?

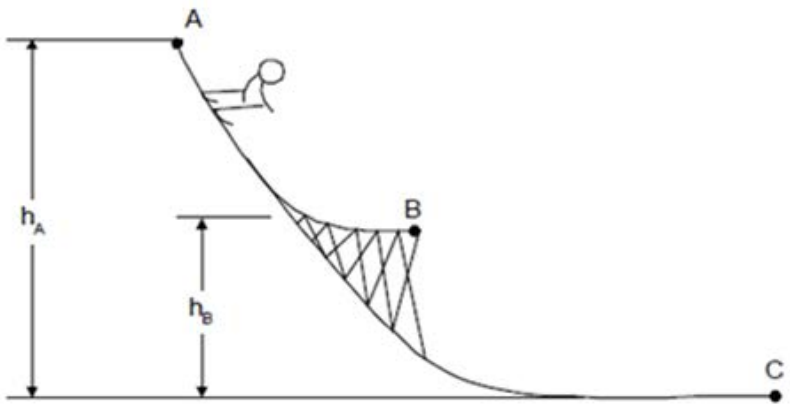
(A) $\sqrt{2gh_B}$

(B) $\sqrt{2gh_A}$

(C) $\sqrt{2g(h_A-h_B)}$

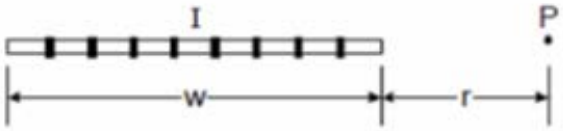
(D) $\sqrt{2gh_Ah_B/(h_A+h_B)}$

(E) $\sqrt{2g(h_A+h_B)}$



Problem 25:

The diagram represent the cross section, a very long thin strip of conductor of width w.



The strip carries a total current I uniformly distributed and directed into the plane of the page. What is the magnitude of the magnetic field due to I at point P in the plane of the strip a distance r from the closer edge?

(A) $\frac{\mu_0 I}{2\pi r}$ (B) $\frac{\mu_0 I}{2\pi(r+w)}$ (D) $\frac{\mu_0 I}{2\pi w}\ln(\frac{r+w}{r})$

(C) $\frac{\mu_0 I}{2\pi(r+w/2)}$ (E) $\frac{\mu_0 I}{2\pi r}\ln(\frac{r-w}{r})$