PART 1: MULTIPLE CHOICE

Instruction: write the letter of your choice in capital in the answer sheet provided.

1. A moving bullet hits a solid target resting on a horizontal frictionless surface and gets embedded in it. Which quantity is conserved?
   A. Momentum alone.
   B. Kinetic energy alone
   C. Both momentum and kinetic energy
   D. Neither kinetic energy nor momentum

2. A 2.0 kg block moving to the right with a speed of 5.0 m/s collides with a 3.0 kg block that is moving in the same direction at 2.0 m/s. After the collision, the 3.0 kg block moves to the right at 4.2 m/s. The velocity of the 2.0 kg block after the collision is
   A. 14.3 m/s B. 2.8 m/s C. 3.0 m/s D. 1.7 m/s

3. A student throws a 0.15 kg rubber ball down onto the floor. The ball's speed just before impact is 6.5 m/s, and just after is 3.5 m/s. What is the change in the magnitude of the ball's momentum?
   A. 0.975 kg. m/s B. 1.5 kg. m/s C. 0.45 kg. m/s D. 0.53 kg. m/s

4. A bomb initially at rest explodes into three fragments. According to the conservation of momentum, the three fragments cannot have
   A. equal masses
   B. equal kinetic energies
   C. the same direction of motion
   D. the same speed

5. If two particles with different masses have equal momenta, the ratio of their kinetic energies
   A. Is equal to one.
   B. Is equal to the ratio of their masses
   C. Equals the ratio of their velocities.
   D. Equals the reciprocal of the ratio of their masses.

6. A constant 9.0-N net force acts for 2.0 s on a 6.0-kg object. What is the object's change of velocity?
   A. 3.0 m/s B. 9.0 m/s C. 27 m/s D.110 m/s

7. A physical quantity that determines whether an object is in thermal equilibrium with other objects is
   A. heat B. temperature C. pressure D. internal energy

8. Two objects, with different sizes, masses, and temperatures, are placed in thermal contact. In which direction does heat energy flow?
   A. From the larger object to the smaller object.
   B. From the object with more mass to the one with less mass.
   C. From the object with less mass to the one with more mass.
   D. From the object at higher temperature to the object at lower temperature.

9. According to the first law of thermodynamics, the internal energy of an ideal gas
   A. increases as the temperature decreases with fixed volume.
   B. increases as the temperature increases with fixed volume.
   C. shows no change when the temperature increases with fixed volume.
   D. shows no change when the temperature decreases with fixed volume.

10. Simple pendulum A swings back and forth at twice the frequency of simple pendulum B. Which of the following statements is correct?
   A. The length of B is four times the length of A
   B. Pendulum B is twice as long as A.
   C. Pendulum B is twice as massive as A.
   D. The mass of B is four times the mass of A.

11. If the amplitude of a mass-spring harmonic oscillator is doubled without changing its mass, the mechanical energy of the system
   A. increases by a factor of two
   B. increases by a factor of three
   C. increases by a factor of four
   D. remains the same

12. Two isolated charges, + q and – 2q, are 2 centimeters apart. If F is the magnitude of the force acting on charge –2q, what are the magnitude and direction of the force acting on charge +q?
   A. 2F, away from charge –2q
   B. F, toward charge – 2q
   C. F, away from charge – 2q
   D. 2F, toward charge – 2q

13. Two isolated charges Q and q attract each other with a force F. If the separation between these charges were reduced by half, then each charge would experience a force of magnitude

   A. 2F/3 B. 2F C. F/2 D. 4F

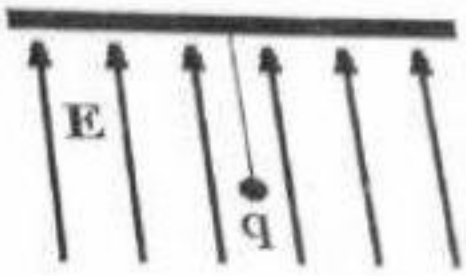
14. A 0.5 gram metallic ball hangs on an insulating string in a vertical electric field of 1,000 N/C and directed upward as shown in the figure. If the tension in the string is 0.004 N, then the charge on the ball is ($g \approx 10\ m/s^2$)

A. $-1.0\ \mu C$

B. $-2.0\ \mu C$

C. $1\ \mu C$

D. $2.0\ \mu C$

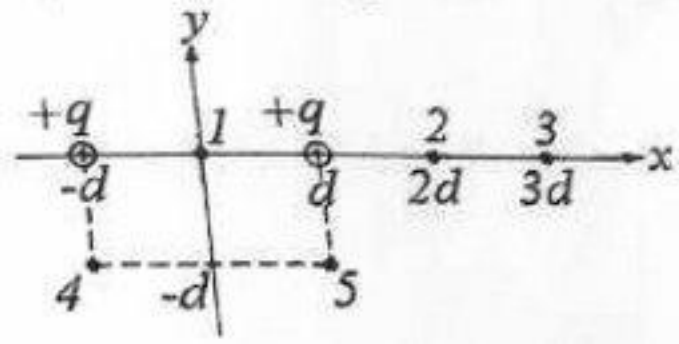


15. A cylindrical electrical conductor has resistivity ρ, resistor R, length L, and diameter D. What will be the new resistance (R_{new}) in terms of the original resistance R if both the length and diameter are doubled?

A. ½R B. 2R C. ¼ R D. 4R

16. At which of the points 1, 2, 3, 4, and 5 is the electric potential greatest in magnitude?

A. 4 and 5
B. 2
C. 3
D. 1

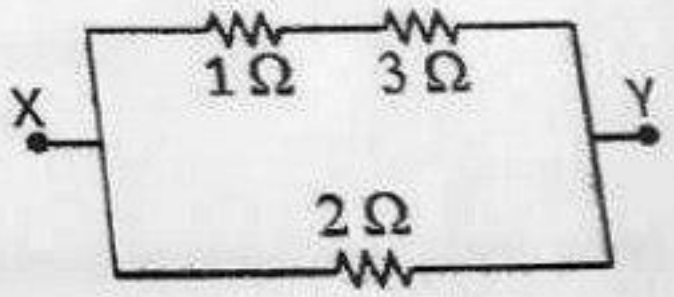


17. Electric potential energy of a system of two point charges, q_1 and q_2, separated by a distance r is given by

A. $k\frac{q_1}{r}$ B. $k\frac{q_2}{r^2}$ C. $k\frac{q_1 q_2}{r}$ D. $k\frac{q_1 q_2}{r^2}$

18. The diagram shows part of a closed electrical circuit. The current in the circuit is

A. greater in the 1 Ω resistor than in the 3 Ω resistor
B. greater in the 2 Ω resistor than in the 3 Ω resistor
C. greater in the 1 Ω resistor than in the 2 Ω resistor
D. greater at point X than at point Y

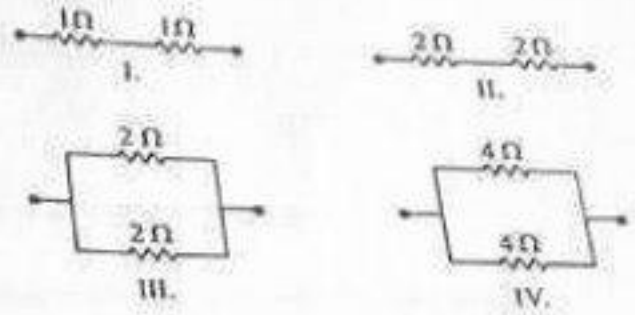


19. An immersion heater of resistance R converts electrical energy into thermal energy that is transferred to the liquid in which the heater is immersed. If the current in the heater is I, the thermal energy transferred to the liquid in time t is

A. I^2Rt
B. IRt
C. IRt^2
D. IR/t

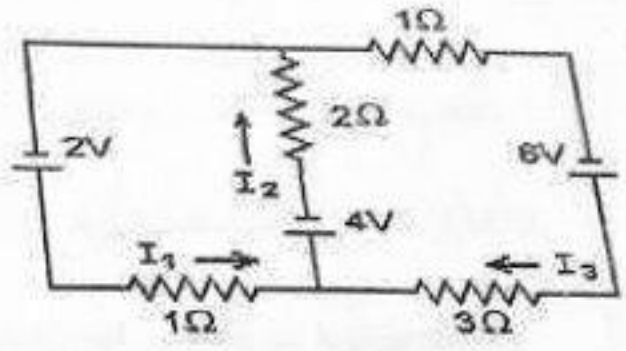
20. Which two arrangements of resistors shown have the same resistance between the terminals?

A. II and III
B. III and IV
C. I and III
D. I and IV



21. Which of the equations here is valid for the circuit shown?

A. $2 - I_1 - 2I_2 = 0$
B. $2 - 2I_1 - 2I_2 - 4I_3 = 0$
C. $4 + I_1 - 4I_3 = 0$
D. $-2 - 2I_1 - 2I_2 = 0$



22. An infinitely long wire carries a current I. The magnetic field outside the wire:

A. points radially away from the wire
B. circles the wire
C. points radially inward toward the wire
D. is zero.

23. A charged particle with constant velocity enters a uniform magnetic field whose direction is parallel to the particle's velocity. The particle will

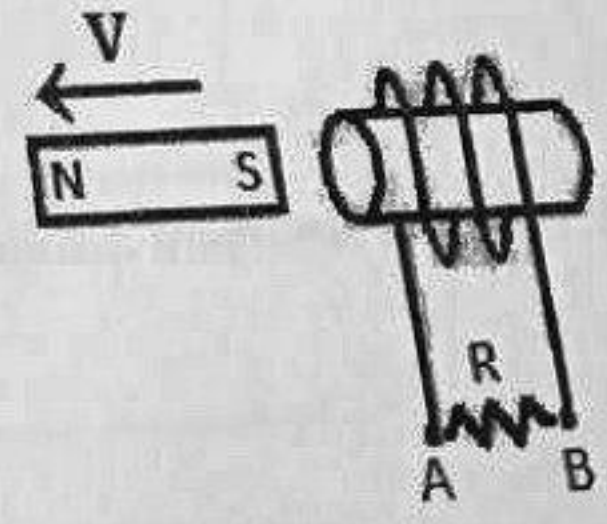
A. speed up
B. slow down
C. follow a circular arc
D. continue with the same velocity

24. The torque on a current loop in a uniform magnetic field is

A. maximum when the magnetic field is parallel to the plane of the loop.
B. maximum when the magnetic field is perpendicular to the plane of the loop.
C. minimum when the magnetic field is parallel to the plane of the loop.
D. Zero when the magnetic field is parallel to the plane of the loop.

25. If a strong bar magnet, shown in the figure, is moved away from the solenoid at constant speed, what is the direction of current through the resistor shown and what is the direction of the force on the magnet because of the induced current?

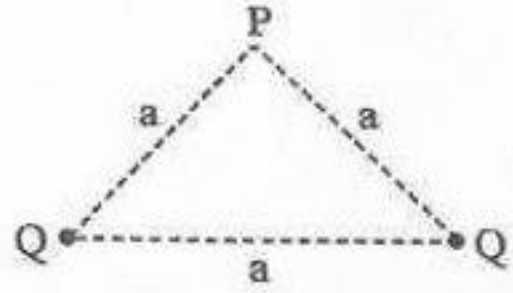
A. Current from A to B and force is to the left
B. Current from B to A and force is to the left
C. Current from A to B and force is to the right
D. Current from B to A and force is to the right



PART 2: SHORT-ANSWER QUESTIONS

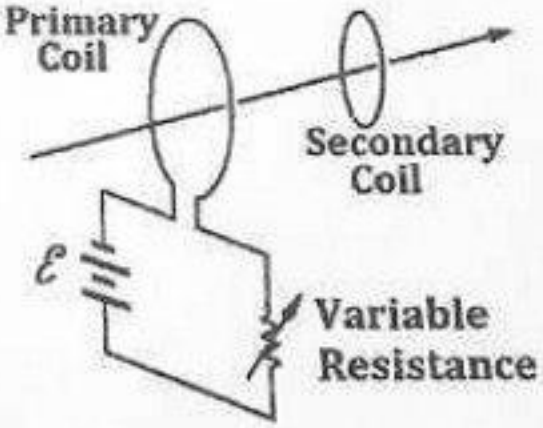
Instruction: Write your responses in the space provided in the Answer Sheet.

1. The momentum of an object is increased by a factor of 4 in magnitude. By what factor is its kinetic energy changed? _____
2. The law that defines temperature is _____.
3. An object attached to one end of a spring makes 20 complete vibrations in 10 s. Its angular frequency is _____.
4. The period of a simple pendulum is 1 s on Earth. When brought to a planet where g is 1/9 of Earth's gravity, its period for the same length becomes _____.
5. A tiny styrofoam ball is suspended on a thread. Tests show it gets attracted to a positively charged rod, and also attracted by a negatively charged rod. The net charge on tiny styrofoam ball is _____.
6. Two equal point charges Q = 2 C are located at the vertices of an equilateral triangle of side length a = 1 m as shown in the figure.



The work done to bring a test charge q = 0.25 nC from infinity to the point P is _____.

7. A battery with internal resistance r = 0.5 Ω and an emf ε = 1.5 V is connected in series to an external resistor of R = 1 Ω. The power dissipated in the battery is _____.
8. The current in the primary coil decreases as the variable resistance is increased. Compared to the current in the primary coil, the current in the secondary coil is in the (same/opposite) _____ direction.



9. An electron is moving at 10×10^5 m/s in the positive y-direction in a uniform magnetic field of 2 T directed in the positive z-direction.

   The direction of the magnetic force on the electron is _____.

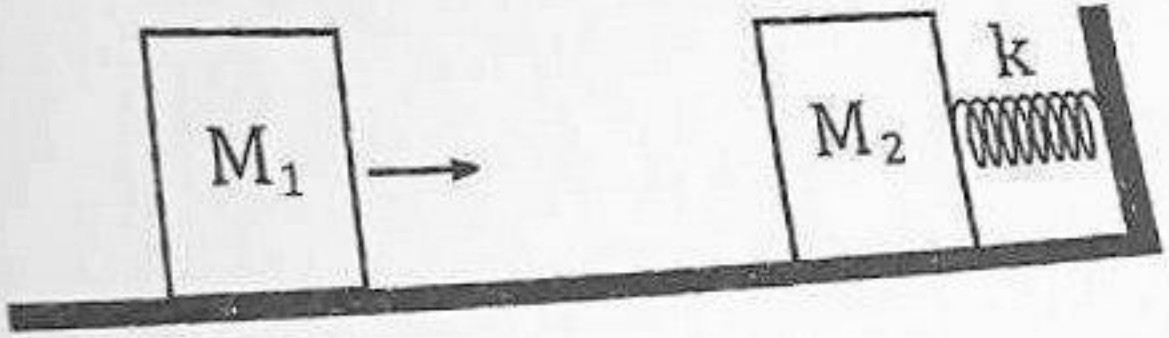
   The magnitude of the magnetic force on the electron is _____.

10. A magnet held stationary near a coil induces current. (TRUE or FALSE?) _____.

PART III: WORK-OUT PROBLEMS

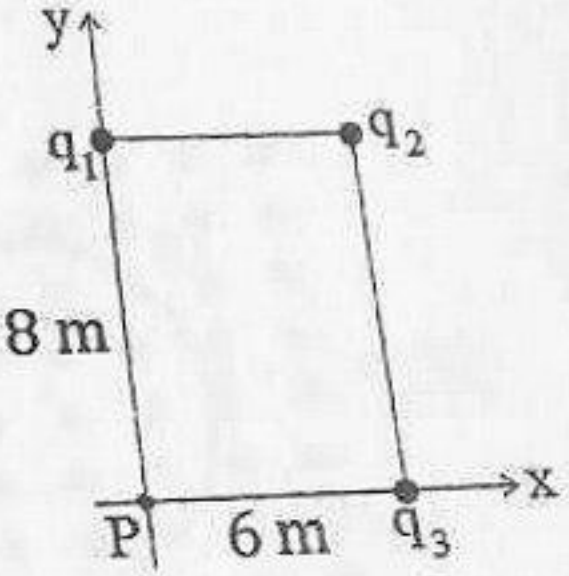
Instruction: Solve the following problems by showing all the necessary steps.

1. A block with mass $M_1 = 4.00$ kg is sliding to the right with a speed of 12.0 m/s when it hits and sticks to a block of mass $M_2 = 2.25$ kg attached to a spring of spring constant $k = 1600$ N/m (See Fig. below). The second block was at the equilibrium position and the spring is relaxed at the time of the collision. The horizontal surface is frictionless. If the combined blocks undergo SHM, find
   a. the maximum compression of the spring,
   b. the angular frequency of oscillation for the system.



Three point charges $q_1 = -64\ \mu C$, $q_2 = 100\ \mu C$, and $q_3 = 36\ \mu C$ are placed at the three corners of a rectangle as shown below. Calculate:

a. the net electric field (magnitude and direction) at point p,
b. the total electric potential at point p, and
c. the potential energy of the system.



OLUTION

Department of Physics, Addis Ababa University

General Physics (Phys1101) Final Semester Examination, September 2021 (Regular Class)

ANSWER SHEET (Exam TYPE A page number at the top)

Part A: Multiple Choice Questions (25 Points)

QN	Answer
1	A
2	D
3	B
4	C
5	D
6	A
7	B

QN	Answer
8	D
9	B
10	A
11	C
12	B
13	D
14	C

QN	Answer
15	A
16	D
17	C
18	B
19	A
20	D
21	C

QN	Answer
22	B
23	D
24	A
25	C

Part B: Short Answer Questions (10 Points)

QN	Answer
1	**sixteen**
2	**the Zeroth law of Thermodynamics**
3	**4π rad/s**
4	**3 s**
5	**zero**
6	**9 J**
7	**0.5 W**
8	**same**
9	**in the negative x direction; magnitude = 3.2×10^{-13} N**
10	**False**

Part C: Workout Problems (15 Points)

Problem #1

a. **(3 Points)** Since the surface is frictionless, mechanical energy of the oscillator after collision remains constant. Thus, applying the law of conservation of mechanical energy to the motion of the oscillator (combined mass) after collision, we see that mechanical energy just after collision is equal to the mechanical energy at maximum compression. That is,

(1 Point) $$\frac{1}{2}(M_1+M_2)V^2=\frac{1}{2}k\,A^2, \qquad (1)$$

where A is the amplitude (maximum compression of the spring) and V is the speed of the combined blocks just after collision, which can be obtained using conservation of linear momentum. We can thus write

(1 Point) $$M_1 v_{i1}=(M_1+M_2)V$$

Solving for V and substituting numerical values:

$$V=\frac{M_1}{M_1+M_2}v_{i1}=\frac{4.00\,kg}{4.00\,kg+2.25\,kg}\times 12.0\,m/s=7.68\,m/s. \qquad (2)$$

Using Eq. (1) and substituting numerical values, we see that

(1 Point) $$A=\sqrt{\frac{M_1+M_2}{k}}V=\sqrt{\frac{4.00\,kg+2.25\,kg}{1600\,N/m}}\times 7.68\,m/s=0.48\,m=48\,cm \qquad (3)$$

b. **(1 Point)** The angular frequency of the oscillator is obtainable from

$$\omega=\sqrt{\frac{k}{M}}=\sqrt{\frac{1600\,N/m}{0\,kg+2.25\,kg}}=256\,rad/s.$$ **(1 Point)**

Problem #2

a. **(2 Points)** The net electric field at point P due to the three charges is

(1 Point)

$$\vec{E}_p = k\left(\frac{|q_1|}{r_1^2}\hat{j} - \frac{|q_2|}{r_2^2}(0.6\hat{i}+0.8\hat{j}) - \frac{|q_3|}{r_3^2}\hat{i}\right) = 9\times10^3(\hat{j}-0.6\hat{i}-0.8\hat{j}-\hat{i})\frac{N}{C}$$

$$= (-14.4\hat{i}+1.8\hat{j})\,kN/C$$

(1 Point)

Magnitude: $|\vec{E}_p| = \sqrt{E_x^2+E_y^2} = 14.5\,kN/C$

Direction: $\beta = \tan^{-1}\left(\frac{E_y}{E_x}\right) = \tan^{-1}\left(\frac{1.8}{-14.4}\right) = -7.12°$ above the negative x-axis

(172.8 ° CCW from the positive x-axis).

b. **(2 Points)** The electric potential at point P due to the three point charges is

$$V_p = k\left(\frac{q_1}{r_1}+\frac{q_2}{r_2}+\frac{q_3}{r_3}\right) = 9\times10^3(-8+10+6)\,V = 72{,}000\,V$$

(1 Point)

(1 Point)

c. **(2 Points)** The potential energy of the three charges is

(1 Point)

$$U = k\left(\frac{q_1q_2}{r_{12}}+\frac{q_1q_3}{r_{13}}+\frac{q_2q_3}{r_{23}}\right) = 9\times10^9\left(\frac{-64\times100\times10^{-12}}{6}+\frac{-64\times36\times10^{-12}}{10}+\frac{100\times36\times10^{-12}}{8}\right)$$

$$= -7.6\,J$$

(1 Point)

Problem #3

a. **(3 Points)** The induced emf is given by

$$\varepsilon = N\frac{\Delta\phi}{\Delta t} = NA\frac{\Delta B}{\Delta t} = 100 \times \pi r^2 \times 2 = 1.57\,V$$

(2 Points) (1 Point)

b. **(2 Points)** The induced current is

$$I = \frac{\varepsilon}{R} = \frac{1.57}{0.5}A = 3.14\,A\ clockwise$$

(1 Point) (1 Point)