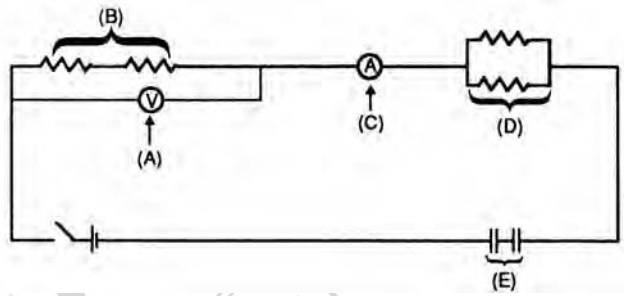
ANSWER KEY

1. E	**12.** B	**23.** D	**34.** D	**45.** A	**56.** E	**67.** D
2. B	**13.** A	**24.** A	**35.** C	**46.** D	**57.** B	**68.** C
3. D	**14.** C	**25.** B	**36.** D	**47.** D	**58.** B	**69.** A
4. B	**15.** B	**26.** B	**37.** E	**48.** A	**59.** C	**70.** A
5. C	**16.** B	**27.** C	**38.** B	**49.** C	**60.** D	**71.** B
6. C	**17.** E	**28.** B	**39.** E	**50.** A	**61.** B	**72.** C
7. A	**18.** D	**29.** C	**40.** E	**51.** C	**62.** B	**73.** B
8. E	**19.** C	**30.** C	**41.** A	**52.** E	**63.** C	**74.** D
9. C	**20.** E	**31.** D	**42.** C	**53.** A	**64.** C	**75.** D
10. A	**21.** B	**32.** D	**43.** B	**54.** B	**65.** D	
11. D	**22.** D	**33.** E	**44.** E	**55.** C	**66.** A	

EXPLANATORY ANSWERS

1. **The correct answer is (E).** Definition.
2. **The correct answer is (B).** Definition.
3. **The correct answer is (D).** Definition.
4. **The correct answer is (B).** See diagram below:



5. **The correct answer is (C).** The ammeter measures current. Recall that the unit of current is the ampere.
6. **The correct answer is (C).** Definition.
7. **The correct answer is (A).** Definition.
8. **The correct answer is (E).** When an object undergoing harmonic motion has a displacement of zero, it is at the equilibrium position. The restoring force will therefore be zero. If the force is zero, then the acceleration must necessarily be zero as well. Recall the relationship:

$$F = ma$$

if $F = 0$,

then $ma = 0$ and $\therefore a = 0$

9. **The correct answer is (C).** The distance value is unchanged.

10. **The correct answer is (A).** Velocity is defined as the change in displacement (distance in this case) per unit time:

$$v = \frac{\Delta d}{\Delta t}$$

Hence, **(A)** has the greatest constant velocity as it has the greatest change in distance per unit time. Note that constant velocity is represented by a straight line in this diagram.

11. **The correct answer is (D).** Acceleration is defined as the change in velocity per unit time:

$$a = \frac{\Delta v}{\Delta t}$$

As lines A, B, and C are straight, each represents a *constant* velocity. Therefore, as acceleration is the *change* in velocity per unit time, the acceleration of A, B, and C is zero. The curvilinear representations—D and E—demonstrate positive and negative accelerations, respectively. Object D has the greatest acceleration as it possesses the greatest change in velocity per unit time.

12. **The correct answer is (B).** Definition. The number of protons plus the number of neutrons within a given nucleus represents the mass number of the element.

13. **The correct answer is (A).** The atomic number is the defining characteristic of an atom.

14. **The correct answer is (C).** Definition.

15. **The correct answer is (B).** Definition.

16. **The correct answer is (B).** Centripetal force is defined by the equation:

$$F = \frac{mv^2}{r} \therefore F = \frac{1}{r}$$

Therefore, force is inversely related to the radius. Consequently, if the radius of the circular path is doubled, the force will be halved.

17. **The correct answer is (E).** As would be expected, the maximum range of an object in projectile motion is dependent on the initial velocity (v_o), the launching angle (q), and the acceleration due to gravity (g). The equation which defines the horizontal range is

$$\text{Range} = \frac{V_0}{g} \sin 2\Theta$$

18. **The correct answer is (D).** A converging lens is said to possess a positive value for the focal length. The thin lens equation relates the focal length, object distance, and image distance as follows:

$$\frac{1}{O} + \frac{1}{i} = \frac{1}{f}$$

O = object distance
i = image distance
f = focal length

Another concept used in this set of problems is magnification (m):

$$m = \frac{i}{O}$$

if $i = O$, $m = 1$, image is same size as object

In this question, -the copies (images) are the same size as the original. Thus, magnification equals 1, and i must equal O. The focal length is given as 10cm. Using the first equation:

$$\frac{1}{O} + \frac{1}{i} = \frac{1}{10\text{cm}}$$

and since $O = i$

$$\frac{1}{O}+\frac{1}{O}=\frac{1}{10\text{cm}}$$
$$\frac{2}{O}=\frac{1}{10\text{cm}}$$
$$O=(2)(10\text{cm})=20\text{cm}$$

19. The correct answer is (C). The images produced are twice the size of the original, so the magnification is 2:

$$m=2 \text{ and } m=\frac{i}{O}$$
$$i=2O$$

Substituting into the thin lens equation and solving:

$$\frac{1}{f}=\frac{1}{O}+\frac{1}{i}=\frac{1}{O}+\frac{1}{20}$$
$$\frac{1}{10\text{cm}}=\frac{2}{20}+\frac{1}{20}$$
$$\frac{1}{10\text{cm}}=\frac{3}{20}$$
$$2O=(3)(10\text{cm})$$
$$O=\frac{30\text{cm}}{2}=15\text{cm}$$

20. The correct answer is (E). No image is produced. The rays of light do not converge to form an image. The image distance then, if the light rays do not converge, can be said to be indefinite. That is, the image distance approaches infinity. If this is the case then,

$$i\to\infty \text{ then } \frac{1}{\text{i}}\to 0$$

So, if the term $\frac{1}{i}$ *approaches zero*, and

$$\frac{1}{f}=\frac{1}{i}+\frac{1}{O}$$

then

$$\frac{1}{f}-\frac{1}{O}=\frac{1}{O}$$

rearranging

$$\frac{1}{f}=\frac{1}{O} \text{ or } O=f$$

Therefore, if the object distance equals the focal length, no image is produced.

21. The correct answer is (B). At a constant temperature, Boyle's law states:

$$P_i V_i = P_f V_f \text{ where } \begin{array}{l} P = \text{pressure} \\ V = \text{volume} \\ i = \text{initial state} \\ f = \text{final state} \end{array}$$

Substituting the values given:

$$(4 \text{ atm})(2l) = (8 \text{ atm}) V_f$$

$$\left(\frac{4 \text{ atm}}{8 \text{ atm}}\right) 2l = V_f$$

$$1l = V_f$$

22. The correct answer is (D). Density is not a vector quantity, while each of the other choices represent a vector quantity.

23. The correct answer is (D). The force producing the acceleration of the blocks is provided solely by the suspended block. The mass being accelerated however, is that due to both blocks. Recalling the second law of motion:

$$F = ma$$

If the weight (force) of each block is 9.8N, and the acceleration due to gravity is 9.8 m/s^2, the mass may be calculated:

$$F = ma$$

$$9.8\text{N} = m(9.8\text{m/s}^2)$$

$$m = \frac{9.8\text{N}}{9.8\text{m/s}^2}$$

$$m = 1 \text{ kg}$$

Thus, the total mass being accelerated is 2kg (two blocks), and the force is the weight of the one suspended block, 9.8N. Therefore:

$$F = ma$$

$$a = \frac{F}{m} = \frac{9.8\text{N}}{2\text{kg}} = 4.9\text{m/s}^2$$

24. The correct answer is (A). The wave trains in answer choices (B), (C), (D), and (E), when superimposed result in destructive interference. That is, the sum of the individual displacements effectively cancel or lower the net amplitude. The wave train pair in answer choice (A), however, adds constructively at each point, to produce an amplitude greater than either wave does alone.

25. The correct answer is (B). The lines of force between a positive charge and a negative charge are directed from the positive charge to the negative charge. The lines of force are also farther apart as the electric field weakens.

26. The correct answer is (B). The resistance of a given conductor is defined by the following relationship:

$$R = P\frac{L}{A} \text{ where } \begin{array}{l} R = \text{resistance} \\ P = \text{resistivity} \\ L = \text{length of conductor} \\ A = \text{cross-sectional area of conductor} \end{array}$$

This relationship makes sense. The longer the conductor, the more likely a given charge will encounter resistance. Also, the smaller the conductor's cross-sectional area, the more likely a given charge will encounter resistance. The resistivity is a constant specific for each conductor. Substituting the new conditions:

$$R = p\frac{\frac{1}{2}L}{2A}$$

$$R = \frac{1}{4}\left(\text{original } R\right)$$

27. The correct answer is (C). The amount of sample remaining represents the amount left after five half-lives:

$$\left(\frac{1}{2}\right)^n = \frac{1}{32}$$

$$n = 5$$

The time of the half-life for this isotope is:

$$t_{1/2} = \frac{28000_y}{5} = 5600y$$

28. The correct answer is (B). Pressure is the force per unit area:

$$P = \frac{F}{A}$$

Substituting and solving:

$$P = \frac{10\text{N}}{4\text{m}^2} = 2.5\text{N}/\text{m}^2 = 2.5Pa$$

29. The correct answer is (C). The potential difference across the labeled capacitor may be calculated from the relationship:

$Q = CV$ where Q = charge, C = capacitance, V = voltage (potential difference)

First, the effective capacitance of the circuit must be calculated. Then, the charge may be calculated. Finally, the potential difference across the specific component may be determined.

For capacitors in series:

$$\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{10\mu F} + \frac{1}{5\mu F}$$
$$= \frac{1}{10\mu F} + \frac{2}{10\mu F}$$
$$= \frac{3}{10\mu F}$$
$$\therefore C_{eff} = \frac{10\mu F}{3} = 3.3\mu F$$

The charge on the plates:

$$Q = CV$$
$$= 3.3\mu F(12V)$$
$$= 4.0 \times 10^{-5}\ C$$

The potential difference across component "*X*":

$$V_x = \frac{Q}{C_x} = \frac{4.0\times10^{-5}C}{10\times10^{-6}F} = 4.0 \text{ volts}$$

30. The correct answer is (C). The rate of flow (R) through a pipe is defined by the following equation:

$R = vA$ where v is fluid speed and A is cross-sectional area of pipe

From the equation of continuity, it is known that the rate of flow through a system (where laminar flow exists) is constant. So

$R_i = R_f$ or $v_iA_i = v_fA_f$ where i and f denote initial and final conditions

Hence, although the velocity and area may change, the rate of flow will remain constant at 2 m^3/s.

31. The correct answer is (D). The law of gravitation is expressed as follows:

$$F = G\frac{m_a m_b}{r^2}$$ where F = gravitational force, G = gravitational constant, m_a = mass of object a, m_b = mass of object b, r = the distance separating the masses

Therefore, it is demonstrated that the velocity of the objects is not a factor.

32. The correct answer is (D). Work is defined as the product of the force applied and the displacement of the object in the direction of the force:

$$W = F \cdot d$$

Thus, the work involved in lifting an object involves the object's weight (its force) and the distance the object is lifted. The distance is simply the height (h) of the building. Substituting:

$$W = F \cdot d$$
$$= mgh$$
$$= (10k)\ (9.8m/s^2)(100m)$$
$$= 9800J$$

This value represents the object's potential energy at that height.

33. The correct answer is (E). As frictional forces are negligible, the potential energy will be converted to kinetic energy. Therefore, the potential energy at the top of the building equals the kinetic energy at the bottom.

34. The correct answer is (D). Recall that energy is related to frequency by the relationship:

$E = hu$ where h is Planck's constant and u is frequency

Therefore, as the frequency of the incident light increases, the energy imparted to the surface will also increase.

35. The correct answer is (C). In a completely elastic collision, kinetic energy is conserved. Momentum (p) is defined by the expression:

$$p = mv$$

Therefore, if the mass and speed of each ball is identical:

$$m_1 v_1 = m_2 m_2$$

However, as each ball has a constant speed, the acceleration is zero for each ball.

36. The correct answer is (D). The first law of thermodynamics does not address the spontaneity of a given process.

37. The correct answer is (E). Diverging lenses produce images with the same characteristics: virtual, erect, and smaller than the object.

38. The correct answer is (B). Arrow B represents a transition resulting in the emission of 12.1eV:

$$-1.5eV - (-13.6eV) = 12.1eV$$

Since energy and frequency are directly related, this transition will also represent a photon with the highest frequency.

39. The correct answer is (E). To produce an electromotive force, the wire must cut across the lines of force of the magnetic field.

40. The correct answer is (E). The person will initially hear a signal with frequency *f*. As the person moves away from the signal, the frequency will become lower. This situation illustrates the Doppler effect.

41. The correct answer is (A). Torque is defined as the product of the force and moment arm of the applied force:

$$\tau = F \cdot l$$

Force is expressed in newtons, and length in meters. The dimensions of force and length:

F = (mass)(acceleration) m = mass

$\tau = (m)(l/t2)$ l = length

t = time

Therefore, the dimensions of torque:

$= (ml/t_2)(l)$

$= ml^2/t^2$, which is equivalent to ml^2t^{-2}

42. The correct answer is (C). As no net force is acting on the object, the acceleration must necessarily equal zero.

43. The correct answer is (B). A rainbow is formed by the dispersion of light. Similarly, the color spectrum produced by shining light through a prism also illustrates this principle.

44. The correct answer is (E). The force between two point charges is described by Coulomb's law:

$$F = k\frac{q_1 q_2}{r^2}$$

Therefore, the force is inversely proportional to the square of the radius. As the distance separating the charges decreases by a factor of 10, the force will increase by a factor of $(10)^2$ or 100:

$$F\alpha\frac{1}{r^2}$$

$$F\alpha\frac{1}{\left(\frac{1}{10r}\right)^2} = \frac{1}{\frac{1}{100r^2}}$$

$$\therefore 100F\alpha\frac{1}{r^2}$$

45. The correct answer is (A). (Pressure) (Volume) = ? units

$$(Pa)(m^3)$$

$$\left(\frac{\mathrm{N}}{m^2}\right)(m^3) = \mathrm{N} \cdot m = \mathrm{JOULE}$$

The joule is the unit of work.

46. The correct answer is (D). Sound waves require a medium for their propagation. Hence, sound waves cannot be propagated in a vacuum.

47. The correct answer is (D). Only choice (D) accurately reflects the data presented.

48. The correct answer is (A). The circuit illustrated in answer choice (A) is equivalent to the schematic illustrated above question 48. The other choices are not equivalent to the "A-shaped" schematic.

49. The correct answer is (C). Power is defined by the relationship

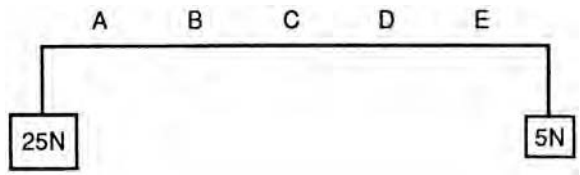
$P = i^2R$ where i is current and

r is resistance

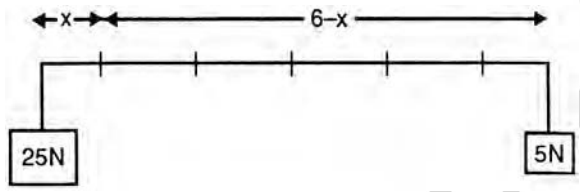
Substituting:

$$P = (2A)^2\,(5\Omega)$$
$$= (4A^2)(5\Omega)$$
$$= 20\text{W}$$

50. The correct answer is (A). For rotation *not* to occur, the clockwise and counterclockwise torques must be equal.



The plank is divided into six sections of equal length. If the plank is lifted at a distance x from one side, then the distance is $6x$ from the other side.



Recall the expression for torque:

$$\tau = F \cdot l$$

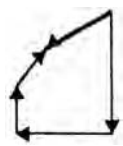
Setting clockwise and counterclockwise torques equal:

$$\tau_{cw} = \tau_{ccw}$$
$$(5\text{N})(6 - x) = (25\text{N})(x)$$
$$30\text{N} - 5\text{N}x = 25\text{N}x$$
$$30\text{N} = 30\text{N}x$$
$$1 = x$$

$\therefore$ The plank should be lifted at one unit length from the left side. This corresponds to (A).

51. The correct answer is (C). The force acts through the object's center of gravity. Therefore the force will produce translational acceleration but will not cause rotational acceleration. Consequently, the rotational equilibrium of the object is unaffected.

52. The correct answer is (E). Adding the vectors graphically:



Choice **(E)** best represents the result.

53. The correct answer is (A). The amount of heat transferred is described by the equation:

$Q = mc\Delta T$ where q = heat transferred, m = mass, c = specific heat capacity, ΔT = temperature change

Substituting:

$$10\ \text{kcal} = (10\ \text{kg})(0.5\ \text{kcal/kg}\ldots\text{C})\Delta T$$

$$\frac{10\ \text{kcal}}{5\ \text{kcal/}\ldots\text{C}} = \Delta T$$

$$\Delta T = 2\ldots\text{C}$$

Since the ice is initially –10°C, the result will be ice at –8°C.

54. The correct answer is (B). This question describes an application of Bernoulli's law. In the case of an airplane wing, air moves more quickly over the top of the wing, and this causes a lower pressure over the top surface. The pressure differential leads to the "lift" of the wing.

55. The correct answer is (C). Choice (C) best represents the force diagram under real conditions. The pulling force acts at an angle θ, friction opposes the direction of motion, gravity acts toward the center of the earth (downward), and the normal force is as illustrated.

56. The correct answer is (E). Mass is a measure of the amount of matter. It is independent of gravitational effects. Therefore, mass is unchanged.

57. The correct answer is (B). Ultrasonic waves are sound waves. Sound does not travel at the speed of light. Each of the other waves travels at the speed of light.

58. The correct answer is (B). By definition, the angle of reflection equals the angle of incidence. The angle of incidence in this case is 90° – θ. Recall, the angle is measured with respect to the normal.

59. The correct answer is (C). Snell's law states

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

For total internal reflection, $\theta_2 = 90°$ and the equation simplifies as $\sin 90° = 1$:

$$\frac{n_2}{n_1} = \sin\Theta_1$$

From the above equation, n_2 must be less than n_1 for total internal reflection to occur. (The sine of an angle cannot exceed 1.)

60. The correct answer is (D). For an ideal gas, it is assumed the gas molecules do not interact. That is, the molecules neither attract nor repulse each other. The remainder of the answer choices represent characteristics of an ideal gas.

61. The correct answer is (B). According to the right hand rule, the current will flow out of the page. Allow the fingers of the right hand to curl in the direction of the magnetic field. The extended thumb represents the direction of the current.

62. The correct answer is (B). The forces between parallel currents are attractive if the currents flow in the same direction. If the parallel currents flow in opposite directions, repulsive forces exist.

63. The correct answer is (C). The astronaut, the space shuttle, and all of the shuttle contents experience the same gravitational force. Thus, everything accelerates toward the earth. Therefore, since the shuttle is accelerating toward the earth, it does not "push" back against the astronaut (like the floor of a building does to someone on earth). Thus, the astronaut feels "weightless."

64. The correct answer is (C). Linear momentum is defined by the expression:

$p = mv$

if $p = 0$, v must also $= 0\,(m \neq 0)$

Since kinetic energy is described by the following equation:

$$\text{K.E.} = \frac{1}{2}mv^2$$

if $v = 0$, K.E. = 0.

Potential energy, however, is independent of the object's velocity.

65. The correct answer is (D). From the second law of motion:

$F = ma$

Since the mass and acceleration are given:

F=(10kg)(1m/s2)

F=10N

The force will produce an acceleration in the direction of the force. Therefore, the net force is 10N to the left.

66. The correct answer is (A). Acceleration is described as the change in velocity per unit time:

$$a = \frac{\Delta v}{\Delta t}$$

In this case, the velocity is unchanged, so the acceleration is zero.

67. The correct answer is (D). In the time period 6–8 seconds, the velocity is constant. Thus, the distance covered continually increases over time. Since the velocity is uniform, the distance versus time graph will be linear with a positive slope.

68. The correct answer is (C). The total magnification of a lens system is simply the product of the magnifying powers of each lens:

$$\begin{aligned}\text{Magnification} &= m_1 \times m_2\\ &=(100)(10)\\ &=1000\text{x}\end{aligned}$$

69. The correct answer is (A). Recall, work is the product of the applied force and the resultant displacement:

$$W = F \cdot d$$

for a charge then, $W = \text{Eq} \cdot d$

However, since no displacement occurs ($d = 0$), the work performed is zero.

70. The correct answer is (A). Impulse is the product of the force and time interval that the force is applied:

$$\text{Impulse} = F\,\Delta t$$

Substituting:

$$2.5\text{Ns} = \left(50\text{N}\right)\Delta t$$

$$\Delta t = \frac{2.5\text{Ns}}{50\text{N}} = 0.05\text{s}$$

$$4_1^1\text{H} \rightarrow {}_2^4\text{He} + 2_1^0\text{e} + \text{energy}$$

71. The correct answer is (B). In the reaction given, four lighter nuclei are combined to form a nuclei with a greater mass. This is an example of fusion.

72. The correct answer is (C). Joule's law describes the heat energy developed in a conductor:

$$W = i^2Rt$$

Substituting:

$$W = (2A)^2\,(6\Omega)(2\text{s})$$
$$= 48\text{ J}$$

Note:

$$(A \cdot \Omega) = \text{C}$$
$$(A \cdot \text{s}) = \text{C}$$
$$v \cdot c = \text{J}$$

73. The correct answer is (B). In the absence of outside forces, angular momentum is conserved. Angular momentum = constant = (angular velocity) × (rotational inertia). Therefore, if the rotational inertia is decreased by bringing the arms close to the body, the angular velocity must increase.

74. The correct answer is (D). Like charges repel each other, while objects of opposite charge will experience a net attractive force. Gravitational forces are much too weak to account for the observed movement.

75. The correct answer is (D). The efficiency of a machine is described by the relationship:

$$\text{Efficiency} = \frac{\text{Useful work output}}{\text{Work input}}$$

The work input is given (100 J). The work output:

$$W = F \cdot d$$
$$= (30\text{N})\,(1.5\text{m})$$
$$= 45\text{ J}$$

Therefore, the efficiency is:

$$\text{Eff} = \frac{45\text{J}}{100\text{J}} = 0.45 \text{ or } 45\%$$