

Physics, 2013 EC, entrance exam, round 1, booklet 41

Grade 12 · Physics · 2013 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes

Questions: 48

Total marks: 48

1. According to the kinetic theory of gases, the (1)
- A. particles of an ideal gas undergo inelastic collision between themselves and with the walls of the container.
 - B. **diffusion rate of a gas is inversely proportional to the square root of the molar mass because it is ✓ directly proportional to the molecular speed.**
 - C. internal energy of an ideal gas is equal to the potential energy due to interaction between the particles of the gas.
 - D. average translational kinetic energy of the particles of an ideal gas increases as the gas gets cooled.

Answer: B

According to Graham's law, the rate of diffusion of a gas is inversely proportional to the square root of its molar mass. This is because the root-mean-square speed of the gas molecules, $v_{rms} = \sqrt{3RT/M}$, is also inversely proportional to the square root of the molar mass.

2. At $t = 0$, an object undergoing SHM has maximum displacement of 0.650 m and angular frequency of 7.40 rad/s. Which of the following is correct about the motion of the oscillator? (1)
- A. ✓ **The position of the object is $x = 0.650 \cos(7.40t)$ and its acceleration is $a = -35.59 \cos(7.40t)$.**
 - B. The frequency of the oscillator is 7.40 Hz and its period is 0.135 s.
 - C. The position of the object is $x = 0.650 \sin(7.40t)$ and its velocity is $v = 4.81 \cos(7.40t)$.
 - D. The position of the object is $x = 0.650 \cos(7.40t)$ and its acceleration is $a = -3.59 \sin(7.40t)$.

Answer: A

With maximum displacement at $t = 0$, the position equation is $x = A \cos(\omega t) = 0.650 \cos(7.40t)$. Since acceleration is $a = -\omega^2 x$, we have $a = -(7.40)^2 \cdot 0.650 \cos(7.40t) = -35.59 \cos(7.40t)$.

3. A 0.35 kg mass attached to the end of a spring oscillates 2.5 times per second with amplitude of 0.15 m. Which (1)
- of the following is true about the motion of the mass?
- A. The velocity when it is 0.10 m from equilibrium is 3.0 m/s.
 - B. The acceleration when it is 0.10 m from equilibrium is 25.00 m/s^2 .
 - C. ✓ **The velocity when it passes the equilibrium is 2.355 m/s.**
 - D. The total energy of the system is 97.0 J.

Answer: C

The maximum velocity of the mass occurs when it passes through the equilibrium position, given by $v_{max} = A\omega = A(2\pi f)$. Substituting the values with $\pi \approx 3.14$, we get $v_{max} = 0.15 \times 2 \times 3.14 \times 2.5 = 2.355 \text{ m/s}$.

4. Identify a true statement about a mechanical wave. (1)
- A. The speed of a wave traveling across a thin string is equal to its speed when traveling across a thick string of the same length and tension.
 - B. **The speed of a wave traveling along a string increases as the tension in the string increases and as the linear density of the string decreases.**
 - C. As a wave travels from one point to another along a medium, it transmits energy and particles of the medium from point to point.
 - D. The velocity of a traveling wave is equal to the velocity of the particles through which the wave propagates.

Answer: B

The velocity of a transverse wave on a stretched string is given by $v = \sqrt{T/\mu}$, where T is the tension and μ is the linear mass density. Therefore, the wave speed increases when tension increases or when the linear density decreases.

5. Which one of the following is a correct statement about the intensity of sound? (1)
- A. It is directly proportional to the square of the distance from the sound source.
 - B. **It is inversely proportional to the square of the distance from the source of sound.**
 - C. It is the product of power of a sound and area through which the sound is transmitted
 - D. It is energy transmitted per unit time.

Answer: B

The intensity I of sound from a point source in an open space is given by $I = P/(4\pi r^2)$, which is inversely proportional to the square of the distance r from the source.

6. Which of the following is correct about Doppler effect? (1)
- A. When a sound source moves away from stationary observer, the frequency detected by the observer increases, whereas the wavelength decreases.
 - B. **Doppler effect is the change in the frequency of a wave due to relative motion between the wave source and an observer.**
 - C. It is the change in the velocity of a wave due to relative motion between the source of the wave and an observer.
 - D. When a source of sound wave moves toward stationary observer, the wavelength of the wave increases while its frequency decreases.

Answer: B

The Doppler effect is defined as the change in the observed frequency of a wave due to the relative motion between the wave source and the observer.

7. Huygens's principle states that (1)
- A. **all points along a wave front behave as a source of spherical secondary wavelets that have the same frequency and speed as the original wave front.**
 - B. front the secondary wavelets are parallel to the original wave front.
 - C. all points along a wave front acts as a source of plane secondary wavelets that travel at speeds and frequencies greater than that of the original wave.
 - D. the secondary wavelets combine to produce a new wave front which has a shape different from the original wave.

Answer: A

Huygens's principle states that every point on a wavefront acts as a source of spherical secondary wavelets that spread out in the forward direction at the speed of the wave.

8. Which one of the following is correct about the law of reflection and the law of refraction? (1)
- A. If the speed of the incident wave is less than the speed of the refracted wave, the refracted wave bends towards the normal line.
 - B. **The ratio of the sine of incident angle to the sine of the refracted angle is equal to the ratio of the speed of incident wave to the speed of the refracted wave.**
 - C. The incident and refracted rays make equal angles with the boundary of the two interface.
 - D. The speed and wave length of a reflected wave are different from that of an incident wave.

Answer: B

According to Snell's law, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is equal to the ratio of the phase velocities in the two media: $\sin \theta_1 / \sin \theta_2 = v_1 / v_2$.

9. Choose the correct statement about interference pattern due to diffraction of light through single and double slits. (1)
- A. The central bright fringes in both double and single slits interference are twice as wide as the first order bright fringes.
 - B. The light intensity of interference pattern due to double and single slits remain the same as the distance from the central bright fringe increases.
 - C. **The bright and dark fringes formed when light passes through double slit have equal widths, whereas the central bright fringe formed in single slit diffraction is twice wider as the first order maxima.**
 - D. Constructive interference due to double slit and single slit interferences occur when the path difference between interfering waves is half-integer multiple of the wavelength.

Answer: C

In a double-slit interference pattern, the bright and dark fringes are of approximately equal width. In contrast, for single-slit diffraction, the central maximum is twice as wide as the higher-order maxima.

10. In order for interference of light waves to occur, the interfering light waves should (1)
- A. be in phase.
 - B. be incoherent.
 - C. be of different types.
 - D. **have constant phase difference and the same frequency and speed.**

Answer: D

For a sustained and observable interference pattern, the interacting light sources must be coherent, meaning they must have a constant phase difference, identical frequency, and identical speed.

11. A scientific method (1)
- A. begins from an accepted scientific theory and concludes with designing an experiment.
 - B. is a scientific procedure where a researcher first predicts the result of a problem before proposing the possible hypothesis.
 - C. is a scientific procedure in which a researcher begins with performing experiments.
 - D. **is a scientific procedure which ensures a rigorous evidence-based structure in which only ideas that have been carefully tested are accepted as scientific theory.**

Answer: D

The scientific method is a systematic, evidence-based procedure involving observation, hypothesis formulation, experimentation, and rigorous testing to ensure only verified ideas become accepted scientific theories.

12. Which one of the following is correct about accuracy and precision of a measurement? (1)
- A. A more accurate measurement has larger uncertainty, whereas a more precise data has smaller uncertainty.
 - B. Accuracy is related to the number of significant figures, whereas precision describes how well we minimize random errors.
 - C. **Accuracy refers to the closeness of repeatedly measured data to a true value, whereas precision is related to the closeness of the measured data to each other.**
 - D. Accuracy describes the closeness of repeatedly measured data to each other, whereas precision describes about the closeness of a data to a true value.

Answer: C

Accuracy refers to how close a measured value is to the true or accepted value, whereas precision refers to the reproducibility of measurements (how close they are to one another).

13. In an experiment to measure the velocity of a ball rolling along x-axis, a student recorded the distance traveled and time taken by the ball. Which of the following data represent constant velocity of the ball? (1)

A. ✓

$x(\text{m})$	0	2	4	6	8	10
$t(\text{s})$	0	1	2	3	4	5

B.

$x(\text{m})$	0	4	5	6	7	9
$t(\text{s})$	0	1	2	3	4	4

C.

$x(\text{m})$	0	2	3	4	6	7
$t(\text{s})$	0	1	2	2.5	3	4

D.

$x(\text{m})$	0	3	5	6	7	9
$t(\text{s})$	0	1	2	3	4	5

Answer: A

Constant velocity implies that the displacement increases by equal amounts in equal time intervals. In option A, the ball travels 2 m in every 1 s interval, representing a constant velocity of 2 m/s.

14. A position vector of an object (1)
- A. is a measure of how fast it is moving relative to stationary reference frame.
 - B. is independent of the origin from which it is measured.
 - C. describes its distance from a given point in all directions.
 - D. **describes its distance from a point in a specified direction.**

Answer: D

A position vector is a vector that represents the location of a point relative to a chosen origin, combining both distance (magnitude) and a specified direction.

15. Consider two force vectors in x-y plane: $F_1 = 10 \text{ N}$ making a 30° angle above the horizontal and $F_2 = 20 \text{ N}$ making a 60° angle above the horizontal. Which of the following is true? (1)
- A. The magnitude of their resultant is 42 N.
 - B. The direction of their resultant vector is 45° above the horizontal.
 - C. The horizontal and vertical components of their resultant are 15 N and 26 N, respectively.
 - D. **The horizontal and vertical components of their resultant are 18.66 N and 22.32 N, respectively.**

Answer: D

The x-component of the resultant is $R_x = 10 \cos(30^\circ) + 20 \cos(60^\circ) = 8.66 + 10 = 18.66 \text{ N}$, and the y-component is $R_y = 10 \sin(30^\circ) + 20 \sin(60^\circ) = 5.00 + 17.32 = 22.32 \text{ N}$.

- 16.** Given four vectors $\vec{A} = 2\hat{i} - \hat{j}$, $\vec{B} = 4\hat{i} - 2\hat{j}$, $\vec{C} = \hat{i} - \hat{j}$, and $\vec{D} = 2\hat{i} + 3\hat{j}$, which pair of these vectors are collinear? (1)
- A. ✓ $\vec{A}$ and $\vec{B}$ B. $\vec{C}$ and $\vec{D}$
C. $\vec{A}$ and $\vec{C}$ D. $\vec{B}$ and $\vec{C}$

Answer: A

Collinear vectors are parallel or antiparallel, meaning one is a scalar multiple of the other. Since $\vec{B} = 4\hat{i} - 2\hat{j} = 2(2\hat{i} - \hat{j}) = 2\vec{A}$, the vectors $\vec{A}$ and $\vec{B}$ are collinear.

17. While going to school, a student travels 3 km, East and then 4 km, North in 2 hrs. The magnitude of student's average velocity and average speed are, respectively
- A. 2 km/hr and 7 km/hr. B. ✓ 2.5 km/hr and 3.5 km/hr.
- C. 3.5 km/hr and 2.5 km/hr. D. 5 km/hr and 7 km/hr.

Answer: B

The total distance is $3 \text{ km} + 4 \text{ km} = 7 \text{ km}$, giving an average speed of $7 \text{ km}/2 \text{ hr} = 3.5 \text{ km/hr}$. The net displacement is $\sqrt{3^2 + 4^2} = 5 \text{ km}$, giving an average velocity of $5 \text{ km}/2 \text{ hr} = 2.5 \text{ km/hr}$.

- 18.** A boy throws a ball vertically upward with an initial speed of 20 m/s. Neglecting air resistance, which of the following is true about the motion of the ball? (1)
- A.** Its velocity after 3s is 50 m/s, downward.
- B.** The time taken to reach the maximum height is 4s.
- C.** Its velocity after 1s is 30 m/s, upward.
- D. ✓ Its maximum height is 20 m.**

Answer: D

The maximum height reached by a projectile thrown vertically upward is $H = u^2/(2g)$. With $u = 20 \text{ m/s}$ and $g = 10 \text{ m/s}^2$, $H = 20^2/(2 \times 10) = 20 \text{ m}$.

19. Choose a correct statement about centripetal force and centripetal acceleration. (1)
- A. Centripetal acceleration and centripetal force are constant in direction, but vary in magnitude.
 - B. **For an object moving in a circular path, its centripetal force and centripetal acceleration are parallel and directed toward the center of the path.**
 - C. Centripetal force on an object moving in a circular path tends to pull the object outward from its path.
 - D. Centripetal force on an object moving in a circular path is perpendicular to the radius of the path.

Answer: B

In uniform circular motion, both the centripetal acceleration and the centripetal force always point in the same direction—radially inward toward the center of the circular path.

20. According to Newton's law of Universal Gravitation, (1)
- A. for two interacting objects, the gravitational force exerted on a light object is less than the force on the heavy one.
 - B. the speed of a satellite moving around the Earth in a circular orbit depends on the mass of the satellite.
 - C. the gravitational attraction between two objects is directly proportional to the square of the distance between them.
 - D. **the period of a satellite orbiting the Earth in a circular orbit increases as the radius of its orbit increases.**

Answer: D

According to Kepler's third law (derived from Newton's law of gravitation), the square of the orbital period T is proportional to the cube of the orbital radius r , meaning the period increases as the radius increases.

21. Which one of the following is correct about diffraction of light? (1)
- A. **✓ As the number of slits of a grating increase, the bright fringes become brighter, taller and narrower.**
 - B. As the width of a single slit decreases, the width of central bright fringe decreases too.
 - C. Diffraction of light passing through a single slit produces bright and dark fringes of equal widths.
 - D. Diffraction of light passing through a circular aperture results in parallel bright and dark fringes.

Answer: A

In a diffraction grating, as the number of illuminated slits increases, the interference maxima (bright fringes) become narrower, more intense (brighter), and more sharply defined.

22. In Millikan's oil drop experiment, (1)
- A. the charge of the droplet was found to be half-integer multiple of electron charge.
 - B. the electric field between the anode and cathode can be increased by decreasing the distance and the potential difference between them.
 - C. tiny droplets of negatively charged mineral oil were balanced under the action of downward electric force and weight.
 - D. **the mass of the droplet was determined by measuring its terminal velocity in the absence of electric field.**

Answer: D

In Millikan's experiment, the mass of each oil droplet was determined by observing its terminal velocity as it fell under gravity alone (with no electric field), where viscous drag balances gravity.

23. Many chemical reactions release energy. Suppose that at the beginning of a reaction, an electron and a proton are separated by 0.110 nm, and their final separation is 0.100 nm. The change in the electric potential energy in this reaction (in eV) is (1)
- A. 13.1 eV.
 - B. **✓ 1.30 eV.**
 - C. 27.5 eV.
 - D. 14.4 eV.

Answer: B

The electric potential energy is $U = -ke^2/r$. The change is $\Delta U = -ke^2(1/r_f - 1/r_i) = -1.44 \text{ eV nm} \times (1/0.100 \text{ nm} - 1/0.110 \text{ nm}) \approx -1.31 \text{ eV}$, which in magnitude is closest to 1.30 eV.

24. When an insulator is placed in an external uniform electric field, (1)
- A. the net electric field within the insulator is greater than the external electric field.
 - B. the induced electric field within the insulator is perpendicular to the external field.
 - C. **electric dipoles are induced within the insulator and produce induced electric field opposite to the external field.** ✓
 - D. the electric field induced within the insulator is greater than the external electric field, but has the same direction as the external field.

Answer: C

An external electric field induces dipoles inside an insulator (dielectric), creating an internal induced electric field that opposes the external field, thereby reducing the net field within the material.

25. Consider a parallel plate capacitor with plate area A , plate separation d , charge Q , capacitance C , potential difference V and electric field E between the plates. The electrical energy density stored by the capacitor (1)
- A. is directly proportional to the electric field E between the plates.
 - B. **✓ is directly proportional to the square of the electric field E between the plates.**
 - C. depends on the plate area A and plate separation d .
 - D. increases as the capacitance C and potential difference V increase.

Answer: B

The electrostatic energy density stored in an electric field is given by the formula $u = \frac{1}{2}\epsilon_0 E^2$, which is directly proportional to the square of the electric field strength E .

26. A potential difference V is applied across the ends of a uniform conducting wire of length l , cross-sectional area A , and containing n free charge carriers per unit volume. Which one of the following is true? (1)
- A. The electric current in the conductor flows perpendicularly to the drift velocity of the free charges.
 - B. **The current density in the conductor is directed in the direction of the drift velocity of the free charge carriers.** ✓
 - C. The free electrons in the conductor flow in the direction of the electric field in the conductor.
 - D. The electric current in the conductor flows arbitrarily in all directions.

Answer: B

By convention, electric current and current density are defined in the direction of the flow of positive charge carriers. Therefore, the current density is directed in the direction of the drift velocity of these charge carriers.

27. According to Kirchhoff's junction rule, (1)
- A. charges can disappear or appear at the junction.
 - B. **✓ the amount of electric charge entering a junction is equal to the amount leaving the junction.**
 - C. the amount of electric charge flowing into a junction is greater than the amount flowing out of the junction.
 - D. the amount of electric charge flowing into a junction is less than the amount flowing out of the junction.

Answer: B

Kirchhoff's junction rule is a statement of the conservation of electric charge, which states that the total current (or charge per unit time) entering a junction must equal the total current leaving it.

28. Which of the following is true about galvanometer? (1)
- A. To use a galvanometer as an ammeter that can read large voltages, we connect a small resistance in series with the galvanometer.
 - B. **A galvanometer can be converted to an ammeter that can read large currents by connecting a small resistance in parallel with it; and can be converted to a voltmeter by connecting a large resistance in series with the galvanometer.**
 - C. To use a galvanometer as an ammeter that can measure large currents, we need to increase its resistance by connecting a large resistance in series with the galvanometer.
 - D. A galvanometer can be converted to a voltmeter by connecting a small resistance in parallel with the galvanometer.

Answer: B

To convert a galvanometer into an ammeter capable of measuring large currents, a very small resistance (shunt) is connected in parallel. To convert it into a voltmeter, a large resistance is connected in series.

29. Equilibrium is the state of an object when (1)
- A. the object has constant angular acceleration.
 - B. **✓ the net force and net torque are both zero.**
 - C. the object has constant linear acceleration.
 - D. the net force acting on it is constant.

Answer: B

An object is in static or dynamic equilibrium when both the net external force acting on it is zero (no linear acceleration) and the net external torque is zero (no angular acceleration).

30. The fulcrum of a uniform 20 kg seesaw that is 4.0 m long is located 2.5 m from one end. A 30 kg child sits on the long end. The weight of a person sitting at the other end in order to balance the seesaw is_____. (1)
- A. **✓ 567 N**
 - B. 433 N
 - C. 850 N
 - D. 750 N

Answer: A

By taking torque about the fulcrum and using $g = 10 \text{ m/s}^2$, the rotational equilibrium equation is $W_p(1.5) = (200)(0.5) + (300)(2.5)$, which yields $W_p \approx 567 \text{ N}$.

31. A material rod that is 4.00 m long and 0.50 cm^2 in cross-sectional area is found to stretch 0.20 cm under a tension of 5000 N. The Young's Modulus for this material is_____. (1)
- A. $5.0 \times 10^8 \text{ N/m}^2$
 - B. **✓ $2.0 \times 10^{11} \text{ N/m}^2$**
 - C. $1.0 \times 10^8 \text{ N/m}^2$
 - D. $1.0 \times 10^4 \text{ N/m}^2$

Answer: B

Using Young's Modulus formula $Y = \frac{FL_0}{A\Delta L}$ with $A = 0.50 \times 10^{-4} \text{ m}^2$ and $\Delta L = 2.0 \times 10^{-3} \text{ m}$, we get $Y = \frac{5000 \times 4.00}{5.0 \times 10^{-5} \times 2.0 \times 10^{-3}} = 2.0 \times 10^{11} \text{ N/m}^2$.

32. Which one of the following is NOT true about Pascal's principle and its application? (1)

- A. **The hydraulic lift is a speed multiplying device in which a large force lifts a light object over a long distance.** ✓
- B. In pneumatic application, air is used for pressure transmission instead of liquid.
- C. It has applications in hydraulic lift in which a small force applied to a smaller piston is used to lift heavy object on large piston.
- D. It has applications in hydraulic brakes for vehicles, where confined oil connects a small piston (brake pedal) to a larger piston connected to the brake drums on the wheel of the car.

Answer: A

A hydraulic lift is a force-multiplying device, not a speed-multiplying device, because the larger force is achieved at the expense of distance (the large piston moves much slower and a shorter distance than the small piston).

33. Which one of the following is NOT correct about factors that affecting the streamlining of objects moving in a fluid? (1)

- A. Shape and surface area of the object moving in a fluid
- B. ✓ **The mass of the object**
- C. Density of the fluid
- D. Compressibility of the fluid

Answer: B

The streamlining of an object is concerned with reducing fluid drag, which depends on the shape, surface area, fluid density, and viscosity, but is entirely independent of the mass of the moving object.

34. Which of the following is correct? (1)

- A. ✓ **Temperature is a measure of the average molecular kinetic energy of a gas.**
- B. Internal energy of a system is independent of its mass or the number of molecules in the system.
- C. Heat is energy that can be transferred from one object to another at equal temperature.
- D. Temperature is a measure of the amount of energy that flows from hot to colder region.

Answer: A

Temperature is a microscopic property that is directly proportional to the average kinetic energy of the random translational motion of the molecules in a substance.

35. Two moles of an ideal gas at a temperature of 308 K is confined in a volume of $5.00 \times 10^{-3} \text{ m}^3$. The pressure of the gas is (Universal gas constant $R = 8.314 \text{ J/mol.K}$) (1)

- A. $5.12 \times 10^6 \text{ Pa}$.
- B. $1.23 \times 10^6 \text{ Pa}$.
- C. $1.00 \times 10^6 \text{ Pa}$.
- D. ✓ **$1.02 \times 10^6 \text{ Pa}$.**

Answer: D

Using the ideal gas law $P = \frac{nRT}{V} = \frac{2 \times 8.314 \times 308}{5.00 \times 10^{-3}} \approx 1.02 \times 10^6 \text{ Pa}$.

36. A glass contains 12 mole of water molecule (H_2O). The number of water molecules, the mass of water, and the mass of each water molecule in the glass are, respectively (Molar mass of H is 1.0 g and O is 16.0 g) (1)
- A. 102×10^{23} molecules, 0.024 kg, 6.02×10^{-26} kg. B. 96.32×10^{23} molecules, 0.036 kg, 0.009×10^{-26} kg.
- C. 72.24×10^{23} molecules, **0.216 kg**, 35.9×10^{-26} kg. D. 90.32×10^{23} molecules, 0.192 kg, 18×10^{-26} kg.
- ✓ **kg.**

Answer: C

The number of molecules is $12 \times 6.02 \times 10^{23} = 72.24 \times 10^{23}$ molecules, and the mass of water is $12 \times 0.018 \text{ kg} = 0.216 \text{ kg}$. Option C is the only choice containing these correct values.

37. Which one of the following statements is correct about thermodynamic processes? (1)
- A. **In an adiabatic process, there is no heat removed from or absorbed by the system and its p-v diagram is a decreasing plot.**
- ✓
- B. An isochoric process occurs at constant pressure and its p-v diagram is horizontal.
- C. An isothermal process occurs at constant pressure and its p-v diagram is a linearly increasing plot.
- D. An isobaric process occurs at constant volume and its p-v diagram is a vertical line.

Answer: A

In an adiabatic process, there is no heat exchange ($Q = 0$). On a p-V diagram, it is represented by a steep, decreasing curve as the gas expands and pressure drops.

38. In a thermodynamic process, $1.5 \times 10^5 \text{ J}$ of heat is added to an ideal gas to keep the pressure constant at $2.0 \times 10^5 \text{ Pa}$ while the volume increase from 6.3 m^3 to 7.1 m^3 . The change in the internal energy of the gas is (1)
- A. $14.1 \times 10^4 \text{ J}$. B. ✓ $-1.0 \times 10^4 \text{ J}$.
- C. $1.0 \times 10^4 \text{ J}$. D. $3.1 \times 10^4 \text{ J}$.

Answer: B

The work done by the gas is $W = P\Delta V = 2.0 \times 10^5 \times (7.1 - 6.3) = 1.6 \times 10^5 \text{ J}$. From the first law of thermodynamics, $\Delta U = Q - W = 1.5 \times 10^5 - 1.6 \times 10^5 = -1.0 \times 10^4 \text{ J}$.

39. Which one of the following is true about fundamental forces? (1)
- A. Electromagnetic force is a long-range attractive force between particles due to their masses.
- B. A weak nuclear force is an extremely short-range force that binds protons and neutrons together in a nucleus.
- C. ✓ **Strong nuclear force is a short-range force that holds protons and neutrons to form atomic nucleus.**
- D. Gravitational force is a long-range attractive force between particles due to their charge.

Answer: C

The strong nuclear force is a short-range, highly attractive force that acts between protons and neutrons, binding them together to form a stable atomic nucleus.

40. Three blocks of mass $M_1 = 1$ kg, $M_2 = 2$ kg, and $M_3 = 3$ kg, placed on a horizontal frictionless table, are connected with strings and pulled to the right by a force $F = 9$ N, as shown below. The acceleration a , tensions T_1 and T_2 are, respectively (1)

[Figure: Three rectangular blocks stand in a row on a horizontal surface drawn as a single straight line. From left to right they are labelled M1, M2 and M3, M3 being the largest and M1 the smallest. A string joins M1 to M2, and above that string a right-pointing arrow is labelled T1. A second string joins M2 to M3, and above it a right-pointing arrow is labelled T2. From the right-hand face of M3 a right-pointing arrow labelled F leads away, showing the applied pull. Nothing else is drawn; no angles, distances or friction marks appear.]

- A. ✓ $a = 3/2$ m/s², $T_1 = 3/2$ N and $T_2 = 9/2$ N. B. $a = 2/3$ m/s², $T_1 = 2/3$ N and $T_2 = 2$ N.
C. $a = 3$ m/s², $T_1 = 3$ N and $T_2 = 9$ N. D. $a = 3/2$ m/s², $T_1 = 3$ N and $T_2 = 9/2$ N.

Answer: A

The acceleration of the system is $a = \frac{F}{M_1 + M_2 + M_3} = \frac{9}{6} = 1.5$ m/s². Thus, $T_1 = M_1 a = 1.5$ N = $3/2$ N and $T_2 = (M_1 + M_2)a = 3 \times 1.5 = 4.5$ N = $9/2$ N.

41. Which of the following is correct about an astronaut inside an international space station orbiting the Earth? (1)

- A. Because the Earth exerts a larger force on the astronaut than on the space station, the astronaut experienced weightlessness.
B. **The astronaut experiences weightlessness because the space station and the astronaut are freely falling towards the center of the earth.** ✓
C. The astronaut experiences weightlessness since the Earth's gravitational force on the astronaut is less than the Earth's force on the space station.
D. Since the Earth exerts equal forces on both the astronaut and the space, the astronaut experiences weightlessness.

Answer: B

The astronaut experiences weightlessness because both the astronaut and the space station are in a state of continuous free fall towards the center of the Earth under the influence of gravity alone.

42. Two masses of m_1 and m_2 are balanced on a horizontal stick of negligible mass pivoted at the center of mass of the system. If the distance from m_1 to the center of mass is 3.0 m and the distance from the mass m_2 to the center of mass is 1.0 m, the ratio of m_1 to m_2 (m_1/m_2) is_____. (1)

- A. ✓ **1/3** B. 3
C. 3/4 D. 4/3

Answer: A

For torque balance about the center of mass, $m_1 d_1 = m_2 d_2$. Substituting the given distances gives $m_1(3.0) = m_2(1.0)$, which yields the ratio $m_1/m_2 = 1/3$.

43. Identify the correct statement about energy, work, and force. (1)

- A. Energy cannot be possessed by an object at rest.
B. Machines can multiply energy but not force.
C. ✓ **Force is a vector quantity, whereas work and energy are scalars.**
D. Work is said to be done by a force whenever the force is exerted on an object.

Answer: C

Force is a vector quantity because it has both magnitude and direction, whereas work and energy are scalar quantities because they only have magnitude.

44. Distinguish between conservative and non-conservative forces.

(1)

- A. A conservative force dissipates energy, whereas a non-conservative force does not.
- B. Friction force is an example of conservative force, whereas spring force and gravitational force are typical examples of non-conservative force.
- C. Work done by a conservative force is path dependent, whereas work done by non-conservative force does not depend on the path followed.
- D. **Work done by a conservative force along any closed path is zero, whereas the work done by non-conservative force along a closed path is not zero.**

Answer: D

By definition, a conservative force is one for which the work done along any closed path is zero, while for a non-conservative force (like friction), the work done along a closed path is non-zero.

45. A crane raises 75.0 kg of bricks from the ground to a height of 45.0 m in 52.0 s at a constant speed. The average power of the crane is_____.

(1)

- A. **✓ 649 W**
- B. 14.4 W
- C. 144 W
- D. 3,375 W

Answer: A

Using $g = 10 \text{ m/s}^2$ for calculations, the work done is $W = mgh = 75 \times 10 \times 45 = 33750 \text{ J}$. The average power is $P = \frac{W}{t} = \frac{33750}{52.0} \approx 649 \text{ W}$.

46. For a rigid body rotating about a fixed axis,

(1)

- A. for the same time interval, a point closer to the axis turns through a smaller angle than a point farther from the axis.
- B. for the same time interval, a point closer to the axis and a point farther from the axis travel the same linear distance.
- C. a point closer to the axis has greater linear speed than a point farther from the axis.
- D. **✓ a point closer to the axis has smaller linear speed than a point farther from the axis.**

Answer: D

In a rotating rigid body, all points share the same angular speed ω . Since linear speed is $v = r\omega$, a point closer to the axis (smaller r) will have a smaller linear speed than a point farther away.

47. A disk of radius 0.10 m and mass 0.1 kg is set into motion by a tangential force of 2.0 N applied at the edge of the disk. If the angular acceleration of the disk is 400 rad/s^2 , the torque and angular velocity at 2.0 s are respectively

(1)

- A. **✓ 0.2 N.m and 800 rad/s.**
- B. 0.5 N.m and 100 rad/s.
- C. 0.1 N.m and 200 rad/s.
- D. 0.2 N.m and 400 rad/s.

Answer: A

The torque is $\tau = FR = 2.0 \times 0.10 = 0.2 \text{ N m}$. The angular velocity at $t = 2.0 \text{ s}$ starting from rest is $\omega = \alpha t = 400 \times 2.0 = 800 \text{ rad/s}$.

48. Identify the correct statement about torque and angular momentum.

(1)

- A. The change in angular momentum is inversely proportional to the torque exerted for a given time interval.
- B. No torque acts on an object when its angular momentum increases.
- C. **A small torque applied for a longer time and a large torque exerted for a shorter time have the same effect on the change of angular momentum.**
- D. For the same time interval, a small torque and a large torque change angular momentum by the same amount.

Answer: C

Since the change in angular momentum is given by $\Delta L = \tau \Delta t$, a small torque acting over a longer duration can produce the same change in angular momentum as a large torque acting over a shorter duration.

— END OF MARKING KEY —

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