

5. Determine the torque in Nm due to a force $\vec{F} = (2\hat{i} + 3\hat{j} + 4\hat{k})\text{N}$ acting at point $\vec{r} = (3\hat{i} + 2\hat{j} + 3\hat{k})\text{m}$ about the origin? (1)
- A. $6\hat{i} + 6\hat{j} + 12\hat{k}$ B. $-6\hat{i} + 6\hat{j} + 12\hat{k}$
 C. $\checkmark$ $17\hat{i} - 6\hat{j} + 13\hat{k}$ D. $-17\hat{i} + 6\hat{j} + 13\hat{k}$

Answer: C

Torque is given by the cross product $\vec{\tau} = \vec{r} \times \vec{F}$. Computing the determinant with $\vec{r} = (3, 2, 3)$ and $\vec{F} = (2, -3, 4)$ yields $\tau_x = 8 - (-9) = 17$, $\tau_y = 6 - 12 = -6$, and $\tau_z = -9 - 4 = -13$, giving $17\hat{i} - 6\hat{j} - 13\hat{k} \text{ N} \cdot \text{m}$.

6. An airplane travelled from Addis Ababa to Mekele, 780km in 45minutes. What was its average speed? (1)
- A. 0.28m/s B. $\checkmark$ **1040km/hr**
 C. 17.3m/min D. 585km/hr

Answer: B

The time of travel is 45 minutes = 0.75 hours. Average speed is $v_{\text{avg}} = \frac{d}{t} = \frac{780 \text{ km}}{0.75 \text{ h}} = 1040 \text{ km/h}$.

7. An example of a body moving with constant speed but still accelerating is (1)
- A. a body moving on a straight road.
 B. a body moving on a straight railway track
 C. $\checkmark$ **a body moving in a circular path**
 D. a body falling in a viscous fluid.

Answer: C

A body moving in a circular path at constant speed undergoes centripetal acceleration because the direction of its velocity vector is continuously changing.

8. A student moves along the boundary of a square field of side 10m in 40sec. if he starts from one end of the corners of the square what will be the magnitude of the displacement of the student at the end of 2 minutes and 20 seconds from his initial position? (1)
- A. 10m B. $\checkmark$ $10\sqrt{2}\text{m}$
 C. 40m D. 30m

Answer: B

The student takes 40 s to complete one full 40 m perimeter. In 2 min 20 s = 140 s, the student completes $\frac{140}{40} = 3.5$ laps, ending at the corner diagonally opposite to the starting point, so the displacement is $\sqrt{10^2 + 10^2} = 10\sqrt{2} \text{ m}$.

9. The graph below illustrates the position and time for a cat that runs to catch a rat and then returns with it. The cat caught the rat after 2 seconds. What was the cat's average speed as it returned with the rat? (1)
- [Figure: A position-time graph on a ruled grid. The vertical axis is labelled "Position (m)" and is marked 0, 1, 2, 3, 4, 5, 6, 7, 8. The horizontal axis is labelled "Time (s)" with major gridlines at 0, 2, 4, 6, 8, 10 and 12 (the 8, 10 and 12 labels are degraded in the scan and print as "R", "1" and "1"). A single continuous line starts at the origin (0 s, 0 m), rises steeply and roughly linearly to about 5 m at 1 s, then continues up to a peak of about 7 m at 2 s. From that peak it falls, first gently, then more steeply, passing about 6 m at 3 s, 5 m at 5 s, 4 m at 6.5 s, 2 m at 8 s, and reaching 0 m at 10 s. Small kinks in the descending line occur near 5 s and near 6.5 s. The stem's apostrophe is corrupted in the capture and renders as a replacement glyph.]
- A. its average return speed was 2m/s. B. its average return speed was 4m/s.
 C. its average return speed was 0.7m/s. D. $\checkmark$ **its average return speed was 0.9m/s.**

Answer: D

The cat catches the rat at $t = 2 \text{ s}$ at a position of 7 m and returns to the origin (0 m) at $t = 10 \text{ s}$. The return distance is 7 m over a time interval of $\Delta t = 10 \text{ s} - 2 \text{ s} = 8 \text{ s}$, yielding an average return speed of $\frac{7 \text{ m}}{8 \text{ s}} \approx 0.9 \text{ m/s}$.

10. A uniform 6m long and 600N beam, rest on two supports as shown. The forces exerted on the beam by the right support B is closes to: (1)

[Figure: A long horizontal rectangular beam drawn in side view, resting on two vertical pillar supports that stand under it. The left support is labelled A and the right support is labelled B. A dimension mark at the top left reads "1m" and spans from the beam's left end to the position of support A. A dimension mark at the top right reads "2m" with arrowheads at both ends and spans from the position of support B to the beam's right end. No other distances or forces are marked on the drawing.]

- A. 75N
B. 240N
C. ✓ 400N
D. 320N

Answer: C

Taking moments about support A: the weight of the beam (600 N) acts at the center of mass, 2 m to the right of A, producing a clockwise torque of $600 \text{ N} \times 2 \text{ m} = 1200 \text{ N}\cdot\text{m}$. Support B is 3 m to the right of A, so for equilibrium the upward force at B must be $1200 \text{ N}\cdot\text{m} / 3 \text{ m} = 400 \text{ N}$.

11. A rod PQ is attached at P to a vertical wall, as shown in the figure below. The length of the rod is 1.8m. The weight W of the rod acts at 0.60m from P. the rod is kept horizontal and in equilibriums by a wire attached to Q and to the wall at R. The wire provides a force F on the rod of 50N at 30° to the horizontal. By taking moments about P determine the weight W of the rod. (1)

[Figure: A right-triangle arrangement against a hatched vertical wall drawn on the left. Two small circles on the wall mark the attachment points: R at the top and P lower down. A horizontal line labelled "rod" runs to the right from P and ends at a small circle labelled Q. A straight line labelled "wire" runs from R down to Q; a small arrowhead on the wire points up and back toward R, indicating the direction of the tension force on the rod. The angle between the wire and the rod at Q is marked 30° (printed as "30°"). A downward arrow drawn from a point on the rod is labelled W; the distance from P to that point is marked "0.6m" and the distance from that point across to the vertical line dropped from Q is marked "1.2m".]

- A. 130N
B. 150N
C. ✓ 75N
D. 50N

Answer: C

Taking moments about the hinge P: the clockwise moment due to the weight is $W \times 0.6 \text{ m}$, and the counter-clockwise moment from the wire is $F \sin(30^\circ) \times 1.8 \text{ m} = 50 \text{ N} \times 0.5 \times 1.8 \text{ m} = 45 \text{ N}\cdot\text{m}$. Setting them equal yields $W = 45 / 0.6 = 75 \text{ N}$.

12. A large mass (A and a small mass (B) are pushing one another apart, as shown in the figure below. The small mass moves away at a velocity of 20m/s to the right. What is the recoil velocity of the large mass? (1)

[Figure: Two rectangular blocks drawn side by side and touching. The larger block on the left is labelled A above it and carries the value "5kg" inside; the smaller block on the right is labelled B above it and carries "2kg" inside. Below the left block a horizontal arrow points to the left, labelled $\vec{V}_A$. Below the right block a horizontal arrow points to the right, and to its right is written $\vec{V}_B = 20 \frac{\text{m}}{\text{s}}$ to the right.]

- A. -20m/s
B. 8m/s
C. 20m/s
D. ✓ -8m/s

Answer: D

By conservation of linear momentum, the total momentum remains zero: $m_A \cdot v_A + m_B \cdot v_B = 0$, which gives $5 \text{ kg} \cdot v_A + 2 \text{ kg} \cdot (20 \text{ m/s}) = 0$. Solving for v_A gives -8 m/s , where the negative sign indicates motion to the left.

13. Find the distance of the center of mass of the system shown in the diagram from point A. The rod is mass less (1)
[Figure: A straight horizontal rod drawn with four small filled circles (point masses) on it. From left to right the masses are labelled above the rod as "3k", "3k", "3k" and "2k" (the labels are truncated in the print; they read as 3 kg, 3 kg, 3 kg and 2 kg). A short tick drops from each mass. The leftmost mass is marked A beneath it. The spacing between the first and second mass is marked "3m", between the second and third "3m", and between the third and fourth "1m".]

- A. ✓ 3.73m
B. 2.09m
C. 2.45m
D. 5.86m

Answer: A

Taking point A as the origin ($x = 0$), the positions of the masses are 0 m (3 kg), 3 m (3 kg), 6 m (3 kg), and 7 m (2 kg). The center of mass is $x_{cm} = (3 \times 0 + 3 \times 3 + 3 \times 6 + 2 \times 7) / (3 + 3 + 3 + 2) = 41 / 11 \approx 3.73$ m.

14. The area under a force versus distance graph represents (1)
A. acceleration
B. the change in energy
C. the change in momentum
D. ✓ work done

Answer: D

By definition, work is the integral of force with respect to displacement ($W = \int F dx$), so the area under a force versus distance graph directly represents the work done.

15. A net external non zero force acts on a particle that is moving along a straight line which one of the following statements is correct? (1)
A. The velocity, but not the kinetic energy of the particle is changing.
B. ✓ Both the velocity and kinetic energy of the particle are changing.
C. The kinetic energy but not the velocity of the particle is changing.
D. The momentum is conserved.

Answer: B

A net external force produces an acceleration along the line of motion, changing the particle's speed and velocity. Since the speed changes, the kinetic energy ($\frac{1}{2}mv^2$) must also change.

16. Which statement is correct about conservative and dissipative force? (1)
A. The work done by conservative forces is path dependent.
B. ✓ The work done along a closed path by non-conservative forces is non zero.
C. Gravitational force is an example of non-conservative force.
D. Friction is an example of conservative force.

Answer: B

For non-conservative (dissipative) forces such as friction, mechanical energy is lost, so the net work done around a closed path is non-zero.

17. The rotational analogue of mass is (1)
A. ✓ moment of inertia
B. torque
C. angular momentum
D. angular acceleration

Answer: A

Moment of inertia measures an object's resistance to changes in its rotational motion, making it the rotational equivalent of mass (inertia in translational motion).

18. If the impulse of a rotating disc is non zero what can you conclude? (1)
- A. The change in linear momentum is zero.
 - B. The torque acting on object is constant.
 - C. Impulse of the disc equals its moment of inertia.
 - D. ✓ **The change in angular momentum is non zero.**

Answer: D

By the angular impulse-momentum theorem, the angular impulse applied to an object equals its change in angular momentum ($J_{\theta} = \Delta L$), so a non-zero impulse implies a non-zero change in angular momentum.

19. The number of joules of heat energy required to raise the temperature of a body by 1k is (1)
- A. ✓ **heat capacity**
 - B. specific heat capacity
 - C. expansion coefficient
 - D. calorific value

Answer: A

Heat capacity is the amount of heat energy needed to raise the temperature of a given body by 1 K. Specific heat capacity refers to this quantity per unit mass.

20. A simple pendulum is made using a long thin metal wire. What happens to the period of the pendulum when the temperature drops? (1)
- A. increase
 - B. remain the same
 - C. ✓ **decrease**
 - D. period of oscillation has random dependence on temperature.

Answer: C

The period of a simple pendulum is $T = 2\pi\sqrt{L/g}$. When temperature drops, the metal wire undergoes thermal contraction, decreasing its length L and therefore decreasing its period of oscillation.

21. Pressure at the bottom of a liquid column is independent of: (1)
- A. ✓ **shape of the column**
 - B. the density of the fluid
 - C. the depth of the point
 - D. the acceleration due to gravity.

Answer: A

Hydrostatic pressure is given by $P = \rho gh$, which depends on the fluid density, acceleration due to gravity, and depth, but is completely independent of the cross-sectional shape or area of the column.

22. A water pipe has a diameter of 5.0cm in the in let side and 1.5cm in the out let side. Water flows at 0.50m^3 per minute at the in let point. What is the speed of the water at the out let point? (1)
- A. ✓ **46.99m/s**
 - B. 13.33m/s
 - C. 74.1m/s
 - D. 148.1m/s

Answer: A

The volume flow rate is $Q = 0.50/60 \text{ m}^3/\text{s} \approx 8.33 \times 10^{-3} \text{ m}^3/\text{s}$. The cross-sectional area at the outlet is $A = \pi(d/2)^2 = \pi(0.015/2)^2 \approx 1.77 \times 10^{-4} \text{ m}^2$, giving a speed $v = Q/A \approx 46.99 \text{ m/s}$.

23. A metal ball has a diameter that is slightly greater than the diameter of a hole that has been cut in to a metal plate. The coefficient of linear expansion for the metal from which the ball is made is greater than that for the metal of the plate. Which one of the following procedures can be used to make the ball pass through the hole? (1)
- A. raise the temperatures of the ball and the plate by the same amount.
 - B. heat the ball and cool the plate.
 - C. ✓ **lower the temperatures of the ball and the plate by the same amount.**
 - D. there is no way of passing the ball through the hole.

Answer: C

Because the metal ball has a higher coefficient of thermal expansion than the plate, cooling both by the same temperature change will cause the ball to contract by a greater amount than the hole, allowing it to pass through.

24. A billiard ball of radius 4cm is falling through a liquid of viscosity 0.985 at a velocity of 2.5m/s the drag force on the ball is (1)
- A. ✓ **$0.591\pi\text{N}$**
 - B. $0.118\pi\text{N}$
 - C. $1.82\pi\text{N}$
 - D. $0.059\pi\text{N}$

Answer: A

By Stokes' Law, the viscous drag force is $F = 6\pi\eta rv = 6\pi \times 0.985 \times 0.04 \text{ m} \times 2.5 \text{ m/s} = 0.591\pi \text{ N}$.

25. Which one of the following statements is correct? (1)
- A. ✓ **Elastic materials retain their shape after deformation.**
 - B. Plastic materials can recover the original size or shape after being distorted.
 - C. Plastic materials change their shape by pressure.
 - D. Elastic materials cannot recover the original size or shape after being distorted.

Answer: A

Elastic materials have the property of recovering or retaining their original shape once deforming forces are removed, whereas plastic materials suffer permanent deformation.

26. Two bodies that are separately in thermal equilibrium with their body must be in thermal equilibrium with each other. This statement is statement of (1)
- A. The first law of thermodynamics.
 - B. ✓ **The zeroth law of thermodynamics.**
 - C. The second law of thermodynamics.
 - D. The third law of thermodynamics.

Answer: B

The zeroth law of thermodynamics states that if two bodies are each in thermal equilibrium with a third body, they are in thermal equilibrium with each other.

27. A device for transforming heat energy to mechanical energy is referred to as (1)
- A. transformer
 - B. Refrigerant
 - C. generator
 - D. ✓ **engine**

Answer: D

A heat engine is a device that absorbs thermal energy from a high-temperature reservoir and converts a fraction of it into mechanical work.

28. Three resistors connected in series have individual voltages labelled Δv_1 , Δv_2 and Δv_3 respectively. Which of the following expresses the value of the voltage Δv_T taken over the three resistors together? (1)

- A. $\checkmark \Delta v_T = \Delta v_1 + \Delta v_2 + \Delta v_3$ B. $\Delta v_T = \Delta v_1 = \Delta v_2 = \Delta v_3$
 C. $\Delta v_T = \left(\frac{1}{\Delta v_1} + \frac{1}{\Delta v_2} + \frac{1}{\Delta v_3} \right)$ D. $\Delta v_T = \left(\frac{1}{\Delta v_1} + \frac{1}{\Delta v_2} + \frac{1}{\Delta v_3} \right)^{-1}$

Answer: A

By Kirchhoff's voltage law, the total potential difference across components connected in series is equal to the algebraic sum of the individual potential differences across each component: $\Delta v_T = \Delta v_1 + \Delta v_2 + \Delta v_3$.

29. What fundamental frequency can a string vibrate at if it is 30cm long and the velocity of traveling waves along the string is 120m/s? (1)

- A. 400Hz B. 600Hz
 C. 800Hz D. $\checkmark$ 200Hz

Answer: D

The fundamental frequency of a string fixed at both ends is given by $f_1 = \frac{v}{2L}$. Substituting $v = 120 \text{ m/s}$ and $L = 0.30 \text{ m}$ yields $f_1 = \frac{120}{2 \times 0.30} = 200 \text{ Hz}$.

30. A wavelength is (1)

- A. A line that represents the direction of propagation of light.
 B. $\checkmark$ **The minimum distance between two points that are in phase.**
 C. The locus of all points of a travelling wave that are in phase.
 D. The number of waves crossing a given plane in a unit time.

Answer: B

Wavelength is defined as the minimum distance between two points on a wave that oscillate in phase with each other.

31. In the sketch below, which best describes the location of the negative charges (electrons) when a negatively charged rod is brought near but not touching the conducting sphere? (1)

[Figure: Four small sketches labelled A, B, C and D, arranged as two columns of two (A above B on the left, C above D on the right). Each sketch shows a long horizontal rod with a rounded right-hand end, drawn covered in short dashes standing for negative charge, with a circle (the conducting sphere) to its right. In sketch A the sphere carries minus signs on its left side (the side facing the rod) and plus signs spread over its right side. In sketch B the sphere carries plus signs on its left side (facing the rod) and minus signs on its right side. In sketch C the sphere is drawn empty, with no charge marks on it at all. In sketch D the sphere carries plus signs on its left side and minus signs on its right side, the same arrangement as B. No numbers or field lines are drawn.]

- A. C B. D
 C. A D. $\checkmark$ B

Answer: D

When a negatively charged rod approaches a neutral conducting sphere, free electrons in the sphere are repelled to the far (right) side, leaving a net positive charge induced on the near (left) side, as shown in sketch B (option D).

32. What is the potential (V) at a distance of 10m from a charge of +5.0C? (1)

- A. $?4.45 \times 10^9 \text{ V}$ B. -0.5V
 C. $\checkmark$ $+4.45 \times 10^9 \text{ V}$ D. +0.5V

Answer: C

The electric potential due to a point charge is $V = \frac{kq}{r}$. Using $k \approx 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$, $V = \frac{8.99 \times 10^9 \times 5.0}{10} = +4.495 \times 10^9 \text{ V} \approx +4.45 \times 10^9 \text{ V}$.

33. A positive charge of $1.0 \times 10^{-4}\text{C}$ is on the negatively charged plate of a parallel plate capacitor as shown below. If the potential(V) on the top plate is +10,000V and that of the bottom plate is -10,000V, how much work (w) is required to move the charge from the bottoms to the top plate? (1)

[Figure: A parallel-plate capacitor drawn in side view. The top plate is a long horizontal rectangle containing a row of eight plus signs. The bottom plate is an identical rectangle containing a row of eight minus signs. Between the plates, closer to the bottom plate, sits a small circle labelled +q. No distances, field lines or potential values are marked on the drawing itself.]

- A. ✓ 2.0J
B. 1.0J
C. zero
D. 2.0×10^4

Answer: A

The work required to move a charge through a potential difference is $W = q\Delta V = q(V_f - V_i)$. Here $\Delta V = 10,000\text{ V} - (-10,000\text{ V}) = 20,000\text{ V}$, so $W = 1.0 \times 10^{-4}\text{ C} \times 20,000\text{ V} = 2.0\text{ J}$.

34. Which statements is Not correct about emission from radioactive isotopes? (1)

- A. Alpha particles are positively charged and less penetrating than beta and gamma.
B. Beta particles are negatively charged and more penetrating than alpha particles.
C. ✓ **Alpha emissions are least influenced by magnetic field.**
D. the most penetrating emissions are gamma particles.

Answer: C

Gamma emissions carry no electric charge and are not deflected by a magnetic field at all, meaning they are the least influenced, not alpha emissions. Statements A, B, and D correctly state the relative penetrating powers of alpha, beta, and gamma radiation.

35. The torque experienced by a current carrying loop, in an external, magnetic field is: (1)

- A. Independent of the number of turns of the loop.
B. Independent of the current in the loop.
C. ✓ **Dependent on the orientation of the loop.**
D. Dependent on magnetic field generated according to Lenz's law.

Answer: C

The magnetic torque on a planar current loop is given by $\tau = NIAB \sin \theta$, which depends directly on the number of turns, the current, the field strength, and the orientation angle θ .

36. Two long wires of the same length and cross sectional area carry the same amount of current. Which one of the following statements is correct about the magnetic field and the magnetic forces on the wires? (1)

- A. ✓ **The magnetic field is zero at the midpoint between the wires when the currents are in the same direction.**
B. The force is attractive between the wires when they carry current in opposite direction.
C. The magnetic fields between the wires reinforce each other when the currents are in the same direction.
D. The magnetic field due to one is proportional to the current through the other wire.

Answer: A

By the right-hand rule, two parallel wires carrying current in the same direction produce magnetic fields that point in opposite directions in the region between them, cancelling to zero exactly at the midpoint.

37. Which conversion process forms the bases for the function of an electric generator? (1)
- A. Alternating current to direct.
 - B. ✓ **Mechanical energy to electrical.**
 - C. Electrical energy to mechanical.
 - D. Low voltage to high voltage or vice versa.

Answer: B

An electric generator operates on the principle of electromagnetic induction to convert mechanical energy into electrical energy.

38. What is the change in magnetic flux in a coil of area 5m^2 as its orientation relative to the perpendicular of uniform 3.0T magnetic field changes from 45° to 90° ? (1)
- A. 0Wb
 - B. ✓ **-11Wb**
 - C. 7.5Wb
 - D. 11Wb

Answer: B

The initial flux is $\Phi_1 = BA \cos(45^\circ) = 3.0 \times 5 \times \frac{\sqrt{2}}{2} \approx 10.6 \text{ Wb}$, and the final flux at 90° is $\Phi_2 = 0 \text{ Wb}$. The change in flux is $\Delta\Phi = \Phi_2 - \Phi_1 \approx -11 \text{ Wb}$.

39. A common unit of energy in atomic physics is (1)
- A. Planck's constant
 - B. ✓ **Electron volt**
 - C. De Broglie wavelength
 - D. Uncertainty principle

Answer: B

The electron volt (eV), defined as the energy gained by an electron accelerated through an electric potential difference of one volt, is the standard unit of energy in atomic and nuclear physics.

40. In photo electric effect, the energy of photoelectrons is proportional to the (1)
- A. ✓ **Frequency of light**
 - B. Intensity of light
 - C. Speed of light
 - D. Absorbance of the metal

Answer: A

According to Einstein's photoelectric equation, the maximum kinetic energy of emitted photoelectrons increases linearly with the frequency of the incident light, whereas the light intensity determines the rate of photoelectron emission.

— END OF MARKING KEY —