

Physics, 2006 EC, entrance exam

Grade 12 · Physics · 2006 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes

Questions: 48

Total marks: 48

1. The distance between two point charges is doubled. What will happen to the force of interaction between the charges? (1)
- A. The force will be doubled.
B. The force will be reduced by half.
C. ✓ **The force will be reduced by a factor of 4.**
D. The force will not be affected.

Answer: C

2. What does the slope of a velocity time graph represent? (1)
- A. distance
B. ✓ **acceleration**
C. displacement
D. speed

Answer: B

3. Moving 2.5×10^{-6} coulomb of charge from point A to point B in an electric field requires 6.3×10^{-4} joule of work. The potential difference between points A and B is approximately (1)
- A. 4.0×10^{-3} V
B. ✓ **2.5×10^{-2} V**
C. 1.6×10^{-19} V
D. 1.0×10^{-14} V

Answer: B

4. A transverse sinusoidal wave is traveling on a string. Which statement is correct about a point on the string? (1)
- A. The point moves in the same direction as the wave.
B. The point moves in simple harmonic motion with a different frequency than that of the wave.
C. ✓ **The point moves in simple harmonic motion with the same angular frequency as the wave.**
D. The point moves in uniform circular motion with a different angular speed than the wave.

Answer: C

5. Two none zero vectors D and E have precisely equal magnitudes. For the magnitude of D + E to be 3 times larger than the magnitude of D - E, what must be the angle between D and E? (1)
- A. 30°
B. 37°
C. 53°
D. ✓ **60°**

Answer: D

6. Which statement is correct about the pressure under a fluid in a container? (1)
- A. It depends on the volume of the fluid.
 - B. ✓ **It depends on the density of the fluid.**
 - C. It depends on the shape of the container.
 - D. It is independent of the depth of the fluid.

Answer: B

7. A capacitor made of parallel plates is charged by connecting it to a battery. The distance between the plates is much less than the surface area of each plate. After fully charged if the plates are disconnected from the battery and then pulled apart a little, what will happen to the total stored energy, the electric field, and the potential difference between the plates? (1)
- A. The electric field between the plates increase.
 - B. ✓ **The potential difference between the plates remain the same.**
 - C. The total energy stored in the capacitor increase.
 - D. The electric field, the potential difference and the stored energy remain the same.

Answer: B

8. Which one of the following statements is true about the motion of a particle in a circular path? (1)
- A. The centripetal acceleration is constant if the particle's speed is constant.
 - B. The tangential acceleration can be perpendicular to the velocity vector of the particle.
 - C. ✓ **The centripetal acceleration is always in the direction perpendicular to the velocity vector of the particle.**
 - D. The acceleration is always perpendicular to the velocity vector of the particle.

Answer: C

9. Two rectangular loops of wire lie in the plane of this paper as shown in the figure below, if the current I in the outer loop is counter clockwise and increases with time, which one of the following statements is correct about the current induced in the inner loop? (1)

[Figure: A line drawing of two concentric rectangles drawn in the plane of the page: a larger outer rectangle and, centred inside it, a smaller inner rectangle. Immediately to the right of the outer rectangle's right-hand side there is a straight vertical line carrying a solid arrowhead at its top, pointing upward, indicating that the current in the outer loop runs upward along that right-hand side (i.e. counter clockwise around the outer loop). No numeric labels appear on the figure; the current symbol I is named only in the stem.]

- A. ✓ **A current is induced in the inner loop in the clockwise direction.**
- B. A current is induced in the inner loop in the counter wise direction.
- C. The induced current in the inner loop creates a magnetic field inside the area bounded by the inner loop in the same direction of the magnetic field that the outer loop produces in this same area.
- D. It is zero.

Answer: A

10. Two men, A and B, are loading identical boxes onto a truck. A lifts his box starting up from the ground to the bed of the truck, whereas B slides his box up a rough ramp to the truck, which statement is correct about the change in the potential energy on the box earth system?

A. ✓ A and B change the potential energy by the same amount.

- B. A changes more potential energy than B.
- C. B changes more potential energy than A.
- D. None of those statements is necessarily true because the force of friction and the angle of the incline is unknown.

Answer: A

11. Two projectiles are fired from ground level at equal speed but different angles. One is fired at an angle of 30 degrees and the other at 60 degrees. The projectile to hit the ground first will be the one fired at (neglect air resistance)

- A. 60 degrees
B. ✓ **30 degrees**
C. both hit at the same time
D. cannot be determined from the given condition.

Answer: B

The time of flight of a projectile launched from ground level is given by $T = (2v_0 \sin \theta)/g$. Since $\sin(30^\circ) = 0.5$ is less than $\sin(60^\circ) \approx 0.866$, the projectile fired at 30° spends less time in the air and hits the ground first.

12. A planet of mass m is circling a star in an elliptical orbital as shown below. Its velocity at point A is $60,000\text{m/s}$ and $r_b = 8r_a$ what is its velocity at point B?

[Figure: A hand-drawn wide ellipse lying horizontally. A small open circle marks the left-hand end of the major axis, labelled A just outside it; another small open circle marks the right-hand end, labelled B just outside it. A star symbol sits on the major axis, well left of centre, representing the star at one focus. A straight horizontal line runs along the major axis from A through the star to B. The segment from A to the star is labelled r_a (written above the line, left of the star) and the much longer segment from the star to B is labelled r_b (written above the line, right of the star). No numeric distances are marked on the drawing.]

- A. ✓ 7,500m/s B. 8,571m/s
C. 60,000m/s D. 788,000m/s

Answer: A

By conservation of angular momentum at the apsides of an elliptical orbit, $m \cdot v_a \cdot r_a = m \cdot v_b \cdot r_b$. Therefore, $v_b = v_a \cdot (r_a / r_b) = 60,000 \text{ m/s} / 8 = 7,500 \text{ m/s}$.

13. A small radio receiver uses a battery that delivers a constant current of 25mA for 3 hours. Calculate the total charge delivered by the battery. (1)

- A. 1080000C
B. 270000
C. 540C
D. ✓ 270C

Answer: D

Total charge is given by $Q = I \cdot t$. Converting the units gives $Q = (0.025 \text{ A}) \cdot (3 \cdot 3600 \text{ s}) = 270 \text{ C}$.

14. A cup of coffee at a temperature of 80°C is placed on table in a 20°C room. What happens to the thermal energy and molecular motion of the coffee when it is left on the table? (1)
- A. ✓ **The thermal energy decreases and the molecules move more slowly.**
- B. The thermal energy increases and the molecules move more slowly.
- C. The thermal energy decreases and the molecules move faster.
- D. The thermal energy increases and the molecules move faster.

Answer: A

As the hot coffee cools down toward room temperature, it loses heat to the surroundings, so its thermal energy decreases. Because temperature is directly proportional to the average kinetic energy of the molecules, the coffee molecules move more slowly.

15. The vector $2\hat{i} + \hat{j} + \hat{k}$ is perpendicular to $\hat{i} + 4\hat{j} + \lambda$ if λ is equal to (1)
- A. -2
- B. -1
- C. ✓ **2**
- D. 3

Answer: C

16. A mass suspended from the end of a spring vibrates up and down 20 times in 36s. What are the frequency and period of the vibration? (1)
- A. ✓ **0.55Hz, 1.8S**
- B. 0.67Hz, 1.5S
- C. 0.0012Hz, 864S
- D. 864Hz, 0.0012S

Answer: A

Frequency is the number of cycles per second: $f = 20 / 36 \text{ s} \approx 0.55 \text{ Hz}$. The period is the reciprocal of the frequency: $T = 36 \text{ s} / 20 = 1.8 \text{ s}$.

17. Determine the total impedance for the circuit shown below (1)
- [Figure: A hand-drawn single-loop series AC circuit. Along the top branch, from left to right: a rectangular resistor box labelled 4Ω above it, then a coil (zig-zag/solenoid symbol) labelled 27mH above it, then a pair of parallel vertical plates (capacitor symbol) labelled 380μ above it. The top branch runs from the top-left corner to the top-right corner of the loop; vertical wires run down both sides. Along the bottom branch there is a source symbol drawn as two small open circles with a sine-wave symbol between them (an AC generator), labelled 110V in large text just above it. No frequency is marked anywhere on the figure, and the capacitor's unit letter after μ is not printed.]
- A. 0Ω
- B. ✓ **4Ω**
- C. 27Ω
- D. 31Ω

Answer: B

The resonant frequency of the circuit is $f_0 = 1 / (2\pi\sqrt{LC}) = 1 / (2\pi\sqrt{0.027 \text{ H} * 380 \mu\text{F}}) \approx 49.7 \text{ Hz}$, which corresponds to the standard 50 Hz AC supply frequency. Near resonance, inductive and capacitive reactances cancel ($X_L \approx X_C$), leaving the total impedance equal to the resistance, $Z \approx R = 4 \Omega$.

18. A hoop of mass M and radius R is at rest at the top of an incline plane of height h. the hoop rolls down the plane without slipping. When the hoop reaches bottom, its angular momentum about its center of mass is: (1)
- A. Mgh
- B. $MR\sqrt{2gh}$
- C. $MR\sqrt{\frac{gh}{2}}$
- D. ✓ **$MR\sqrt{gh}$**

Answer: D

By conservation of energy, $Mgh = (1/2)Mv^2 + (1/2)I\omega^2$; for a hoop $I = MR^2$ and $v = \omega R$, so $Mgh = Mv^2$, giving $v = \sqrt{gh}$. The angular momentum about the center of mass is $L = I\omega = (MR^2)(v/R) = MRv = MR\sqrt{gh}$.

19. What is the resistance of a copper cable if it has a cross sectional area of 1cm^2 and a length of 2km ? The resistivity of copper is $2 \times 10^{-8} \Omega\text{m}$. (1)
- A. 0.0004Ω B. 0.004Ω
C. 0.04Ω D. ✓ 0.4Ω

Answer: D

Using $R = \rho L/A$ with $A = 1\text{cm}^2 = 10^{-4}\text{m}^2$ and $L = 2000\text{m}$: $R = (2 \times 10^{-8} \Omega\cdot\text{m})(2000\text{m}) / (10^{-4}\text{m}^2) = 0.4 \Omega$.

20. When a load of 500kg is hanging from a steel wire of length 3m and cross sectional area 0.20cm^2 , the wire stretches beyond its no load length. If the Young's modulus for the wire made of steel is $Y = 2 \times 10^{11} \text{Pa}$, what is the change in length of the wire beyond its no load length? (1)
- A. ✓ 3.75mm B. 2.75mm
C. 1.75mm D. 0.75

Answer: A

Using Hooke's law, $\Delta L = \frac{FL}{AY}$. With $F = mg = 500\text{kg} \times 10\text{m/s}^2 = 5000\text{N}$, $L = 3\text{m}$, $A = 0.20 \times 10^{-4}\text{m}^2$, and $Y = 2 \times 10^{11} \text{Pa}$, we find $\Delta L = \frac{5000 \times 3}{2 \times 10^{-4} \times 2 \times 10^{11}} = 3.75 \times 10^{-3}\text{m} = 3.75\text{mm}$.

21. As shown in Figure below, two blocks are connected by a string of negligible mass passing over a pulley of radius $r = 0.2\text{m}$ and moment of inertia I . The block on the frictionless incline is moving with a constant acceleration $a = 2.0\text{m/s}^2$ up along the incline. What is the moment of inertia of the pulley? (1)
- [Figure: A hand-drawn right-triangular wedge sitting on horizontal ground, with the right angle at the bottom right; the sloping face rises from the lower left to the apex at the top right, and the angle between the slope and the ground is marked with an arc labelled 37° . A square block labelled 15kg rests on the sloping face. A string leaves the top of that block, runs up the slope parallel to the incline (labelled T_1 above it), passes over a circular pulley drawn at the apex of the wedge, and then hangs vertically down the right-hand vertical face (labelled T_2 to the right of it) to a square block labelled m_2 , with ' 20kg ' printed to the right of that block.]
- A. ✓ 0.8kgm^2 B. 1.25kgm^2
C. 4kgm^2 D. 40kgm^2

Answer: A

Using $g = 10\text{m/s}^2$, for the hanging mass $T_2 = m_2(g - a) = 20(10 - 2) = 160\text{N}$. For the mass on the incline, $T_1 = m_1(a + g \sin 37^\circ) = 15(2 + 6) = 120\text{N}$. From torque on the pulley, $(T_2 - T_1)r = I(a/r)$, giving $I = (160 - 120)(0.2)^2/2.0 = 0.8\text{kg} \cdot \text{m}^2$.

22. A viewing screen is separated from a double slit by 4.80m . The distance between the two slits is 0.030mm . Monochromatic light is directed toward the double slit and forms an interference pattern on the screen. The first dark fringe is 4.50cm from the center line on the screen. What is the wavelength of the light? (1)
- A. 1250nm B. ✓ 7200nm
C. 2500nm D. 5625nm

Answer: B

23. A horizontal pipe of 10cm in diameter has a smooth reduction to a pipe of 5cm in diameter. If the pressure of the water in the larger pipe is 80kPa and the pressure in the smaller pipe is 6kPa , at what rate does the water flow through the smaller pipe? (1)
- A. 1.63m/s B. 6.53m/s
C. ✓ 13.6m/s D. 42.67m/s

Answer: C

24. An aluminium block of mass $m_1 = 3\text{kg}$ and a copper block of mass $m_2 = 5\text{kg}$ are connected by a light string over a frictionless pulley. They sit on a steel surface as shown in figure below, where $\theta = 53^\circ$. The coefficient of kinetic friction between the steel surface and each block is 0.3. If the blocks are released from rest, what is the tension T in the string? (1)

[Figure: A hand-drawn steel block shaped like a wedge with a flat horizontal top on the left and a face sloping down to the right; the word 'Steel' is printed inside the body. A rectangular block labelled m_1 sits on the flat horizontal top surface. A string runs horizontally to the right from m_1 , passes over a small circular pulley mounted at the top corner where the horizontal surface meets the sloping face, then runs down along the sloping face to a square block labelled m_2 resting on that slope. At the bottom of the slope, an arc marks the angle between the sloping face and the horizontal, labelled θ . No numeric values appear on the drawing itself.]

- A. 29.40N
B. ✓ 17.25N
C. 12.25N
D. 8.60N

Answer: B

Using $g = 10\text{ m/s}^2$, the net driving force along the string is $m_2g \sin 53^\circ - \mu m_2g \cos 53^\circ - \mu m_1g = 40 - 9 - 9 = 22\text{ N}$. The acceleration is $a = 22/(3 + 5) = 2.75\text{ m/s}^2$. The tension is $T = m_1a + \mu m_1g = 3(2.75) + 9 = 17.25\text{ N}$.

25. An object of mass 3kg hangs from three light inextensible wires as shown in figure below. Two of the wires make angles $\theta_1 = 53^\circ$ and $\theta_2 = 37^\circ$ with the horizontal. If the system is in equilibrium, what will be the tensions T_1 and T_2 in the wires? (1)

[Figure: A hand-drawn figure showing a horizontal ceiling at the top, drawn as a straight line with hatching strokes above it. Two wires run down from the ceiling and meet at a common knot below and between them, forming a V. The left wire makes an angle with the ceiling marked by an arc labelled θ_1 , and the wire itself is labelled T_1 below and to the left. The right wire makes an angle with the ceiling marked by an arc labelled θ_2 , and that wire is labelled T_2 below and to the right. From the knot a third, vertical wire runs straight down to a solid rectangular block, and a short vertical arrow points downward from the bottom of the block (its weight). No numeric values are written on the drawing.]

- A. $T_1 = 18\text{N}$ and $T_2 = 24\text{N}$
B. $T_1 = T_2 = 18\text{N}$
C. $T_1 = T_2 = 24\text{N}$
D. ✓ $T_1 = 24\text{N}$ and $T_2 = 18\text{N}$

Answer: D

Resolving forces at the junction, $T_1 \cos 53^\circ = T_2 \cos 37^\circ \implies 0.6T_1 = 0.8T_2$, so $T_1 = \frac{4}{3}T_2$. Vertically, $T_1 \sin 53^\circ + T_2 \sin 37^\circ = mg = 30\text{ N}$, which gives $(\frac{4}{3}T_2)(0.8) + 0.6T_2 = \frac{5}{3}T_2 = 30\text{ N}$, yielding $T_2 = 18\text{ N}$ and $T_1 = 24\text{ N}$.

26. An object of mass m is hung from a spring and set into oscillation. The frequency of the oscillation is measured and recorded as f . If the object of mass m is replaced with an object of mass $2m$ and set into oscillation, what will be the frequency of the motion? (1)

- A. ✓ $f/\sqrt{2}$
B. f
C. $(\sqrt{2})f$
D. $2f$

Answer: A

The frequency of a mass-spring system is $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$. Doubling the mass scales the frequency by a factor of $1/\sqrt{2}$, giving $f/\sqrt{2}$.

27. A placekicker must kick a football from a point which is at a distance of 36.0 m from the goal. When kicked, the ball leaves the ground with a speed of 20.0 m/s at an angle of 37° to the horizontal. If the ball hits the crossbar of the goal at a height h and bounces back, what will be the height of the crossbar? (1)

- A. 2.45m
B. ✓ 2.85
C. 3.00m
D. 3.15m

Answer: B

28. A body moving with constant acceleration covers the distance between two points 60m apart in 5s. Its velocity as it passes the second point is 15m/s. what is the acceleration? (1)

A. 3m/s^2 B. 2.4m/s^2
C. 1.8m/s^2 D. ✓ 1.2m/s^2

Answer: D

Using the kinematic formula $s = vt - \frac{1}{2}at^2$, we substitute $60 = 15(5) - \frac{1}{2}a(5)^2 = 75 - 12.5a$. Solving gives $12.5a = 15$, so $a = 1.2 \text{ m/s}^2$.

29. Which of the following combinations of properties would be most desirable for a heat sink in a machine? (1)

A. ✓ **high specific heat and low conductivity.**
B. low heat specific heat and low conductivity.
C. high specific heat and high conductivity.
D. low specific heat and low conductivity.

Answer: A

30. A 6V battery is connected across the primary coil of a transformer having 50 turns. If the secondary coil of the transformer has 100 turns, what voltage appears across the secondary? (1)

A. 24.0V B. ✓ **12.0V**
C. 6.00V D. 3.00V

Answer: B

Using the transformer turns ratio equation, $V_s = (N_s / N_p) * V_p = (100 / 50) * 6.0 \text{ V} = 12.0 \text{ V}$. Note that in strict physical terms, a steady DC battery produces zero continuous voltage across a transformer secondary, but 12.0 V is the intended answer from the turns ratio formula.

31. The change in entropy is zero for: (1)

A. reversible isobaric processes.
B. reversible adiabatic processes.
C. ✓ **reversible isothermal processes.**
D. reversible processes during which no work is done.

Answer: C

32. Two particles with masses 2m and 3m are moving toward each other along the x axis with the same initial speed v. Particle 2m is traveling to the left, and particle 3m is traveling to the right. They undergo an elation glancing collision such that particle 2m is moving in the negative y direction after the collision. What are the x component of the final velocity of particle 3m and the kinetic energy of particle 2m, respectively? (1)

A. $0.33v$ and $0.7mV^2$ B. ✓ **$0.33v$ and $1.41mV^2$**
C. $0.67v$ and $0.71mV^2$ D. $0.67v$ and $1.4mV^2$

Answer: B

By conservation of momentum in the x-direction, $(3m)(v) - (2m)(v) = (3m)v_{3x} + 0$, giving $v_{3x} = v/3 \approx 0.33v$. Conservation of momentum in the y-direction and conservation of total kinetic energy together yield a final kinetic energy for particle 2m of $(7/5)mv^2 = 1.4mv^2$ (given as $1.41mv^2$ in option B).

33. Two separate coherent sources produce waves whose wavelengths are 0.10m. which statement is correct about points that are 3.2m away from one source? (1)

A. ✓ **constructive interference occurs if the points are 3.0m from the other source**
B. constructive interference occurs if the points are 3.05m from the other source.
C. constructive interference occurs if the points are 2.95m from the other source.
D. destructive interference occurs if the points are 3.2m from the other source.

Answer: A

Constructive interference occurs when the path difference is an integer multiple of the wavelength ($m \cdot \lambda$). Here, $|3.2 \text{ m} - 3.0 \text{ m}| = 0.20 \text{ m} = 2 \cdot (0.10 \text{ m}) = 2 \cdot \lambda$, which satisfies the condition for constructive interference.

34. A coil formed by wrapping 50 turns of wire in the shape of a square is positioned in a magnetic field so that the normal to the plane of the coil makes an angle 37° with the direction of the field. When the magnetic field is increased uniformly from 200 mT to 600mT in 4.00s, an emf of magnitude 160.0 mv is induced in the coil. What is the total length of the wire in the coil? (1)

A. 100m
B. 200m
C. 300m
D. ✓ **400m**

Answer: D

35. The half-life of radium 224 is 3.5 days. What fraction of the sample remains undecayed after fourteen days? (if needed use $\ln 2 = -\ln(1/2) \approx 0.693$) (1)

A. ?
B. ✓ **$\frac{1}{16}$**
C. $\frac{1}{8}$
D. $\frac{1}{16}$

Answer: B

36. Two positive charges of magnitude q are each a distance d from the origin A of a coordinate system as shown below. The magnitude of the electric field is minimum at point (1)

[Figure: A hand-drawn coordinate diagram. A horizontal axis runs across the figure with an arrowhead at the right end labelled X; a vertical axis rises from the origin with an arrowhead at the top labelled Y, and the origin itself is marked with a solid dot (this is point A named in the stem). Two small open circles sit on the horizontal axis, each labelled $+q$ above it: one a distance d to the left of the origin and one a distance d to the right of the origin. The two spacings are marked underneath the axis by short dashed segments each labelled d . Further to the right along the horizontal axis there are two solid dots: the nearer one labelled B (above it) and the farther one labelled C (above it), with ' $3d$ ' printed just below the point C. Below the axis, dashed vertical lines drop from each of the two $+q$ charges to a dashed horizontal line, forming an open rectangle; the lower-left corner of that dashed rectangle is a solid dot labelled D and the lower-right corner is a solid dot labelled E.]

A. ✓ **A**
B. B
C. C
D. D

Answer: A

Point A is at the origin, exactly halfway between the two identical positive charges $+q$ at $x = -d$ and $x = +d$. By symmetry, their electric fields are equal in magnitude and opposite in direction, canceling completely to give a minimum electric field magnitude of zero.

37. If the terminals of a battery with zero internal resistance are connected across two identical resistors in series, the total power delivered by the battery is 8 W. If the same is connected across the same resistors in parallel, what is the total power delivered by the battery? (1)

A. 2W
B. 4W
C. 16W
D. ✓ 32W

Answer: D

In series, the equivalent resistance is $2R$ and the power is $P_{\text{series}} = V^2 / (2R) = 8 \text{ W}$, so $V^2 / R = 16 \text{ W}$. In parallel, the equivalent resistance is $R/2$, giving $P_{\text{parallel}} = V^2 / (R/2) = 2(V^2 / R) = 2 * 16 \text{ W} = 32 \text{ W}$.

38. Wire B has twice the length and twice the radius wire A. Both wires are made from the same material. If wire A has a resistance R , what is the resistance of wire B? (1)

A. $4R$
B. $2R$
C. ✓ $R/2$
D. $R/4$

Answer: C

Resistance is proportional to length and inversely proportional to cross-sectional area (proportional to r^2). Doubling the length doubles the resistance, but doubling the radius quadruples the area, resulting in $R_B = R * (2 / 2^2) = R/2$.

39. The sound level at a distance of 4.00m from a source is 120dB. At what distance is the sound level 100dB? (1)

A. 0.40m
B. 4.80m
C. ✓ 40m
D. 48m

Answer: C

A decrease of 20 dB in sound level corresponds to an intensity decrease by a factor of 100. Since intensity varies inversely with the square of distance ($I \propto 1/r^2$), the distance must increase by a factor of 10, from 4.00 m to 40 m.

40. An ideal gas is at a temperature of 300K. If we wish to double the root mean square (rms) speed of the molecules of the gas, to what value must we raise its temperature? (1)

A. 450K
B. 600K
C. 800K
D. ✓ 1200K

Answer: D

The root-mean-square speed of gas molecules is proportional to the square root of absolute temperature ($v_{\text{rms}} \propto \sqrt{T}$). To double the rms speed, the absolute temperature must be quadrupled: $4 \times 300 \text{ K} = 1200 \text{ K}$.

41. Suppose that the index of refraction of a soap bubble film is 1.25, what is the minimum thickness of the soap-bubble film that results in constructive interference in the reflected light if the film is illuminated with light whose wavelength in free space is $\lambda = 600\text{nm}$? (1)

A. 120nm
B. 150nm
C. 300nm
D. ✓ 450nm

Answer: D

42. A wire carries a steady current of 2.4A. A straight section of the wire is 0.75m long and lies in xy-plane along the x-axis within a uniform magnetic field, $B=1.6\text{kT}$. If the current is in the positive x direction, what is the magnetic force on the section of wire? (1)

A. 2.88N, in the negative y direction.
B. ✓ 2.88N, in the positive y direction.
C. 3.84N, in the negative y direction.
D. 3.84N, in the positive y direction.

Answer: B

43. Two different capacitors of capacitance $C_1 = 2\mu\text{F}$ and $C_2 = 3\mu\text{F}$ are connected in series across a 120V supply line. The charged capacitors are disconnected from the line and from each other, and reconnected with terminals of like sign together. What will be the final charges on C_1 and C_2 respectively? (1)
- A. ✓ $57.63\mu\text{C}$ and $86.4\mu\text{C}$ B. $115.2\mu\text{C}$ and $127.8\mu\text{C}$
C. $144\mu\text{C}$ across each D. $288\mu\text{C}$ across each

Answer: A

44. A glass flask whose volume is exactly $1,000\text{cm}^3$ at 0°C is totally filled with 1000cm^3 of mercury at this temperature. When flask and mercury are heated to 100°C , 15.2cm^3 of mercury overflow. If the coefficient of volume expansion of mercury is 1.82×10^{-4} per Celsius degree, what should be the coefficient of volume expansion of the glass? (1)
- A. $1.52 \times 10^{-4}/^\circ\text{C}$ B. $1.82 \times 10^{-4}/^\circ\text{C}$
C. ✓ $3.00 \times 10^{-4}/^\circ\text{C}$ D. $1.00 \times 10^{-5}/^\circ\text{C}$

Answer: C

45. A heat engine is being designed to have a Carnot efficiency of 65.0% when operating between two energy reservoirs. If the temperature of the cold reservoir is 20.0°C , what must be the temperature of the hot reservoir? (1)
- A. ✓ 570°C B. 3100°C
C. 5640°C D. 8070°C

Answer: A

46. In Figure given below, the current in the 16Ω resistor is (1)
[Figure: A hand-drawn circuit with a left vertical rail and a right vertical rail joined by three horizontal branches. Top branch, from left to right: a battery symbol (long and short parallel plates) with '24V' printed above and to its left, then a zig-zag resistor labelled 28Ω above it; a horizontal arrow pointing to the right near the right-hand end of this branch is labelled I_1 . Middle branch, from left to right: a second battery symbol with no voltage label printed, then a zig-zag resistor labelled 12Ω above it; below and to the right of this branch a horizontal arrow points to the right, labelled I_2 . Bottom branch: a zig-zag resistor labelled 16Ω below it, with a horizontal arrow above the branch pointing to the LEFT, labelled I_3 .]
- A. 0.64A B. 0.15A
C. ✓ 0.49A D. 1.28A

Answer: C

47. A 10.0m uniform ladder weighing 200N rests against a frictionless wall. The ladder makes 53° angles with the horizontal, if the ladder is just on the verge of slipping when a 600.0N firefighter is 6.00m along the ladder from the bottom, what is the coefficient of static friction between the ladder and ground? (1)
- A. 0.3240 B. ✓ 0.4313
C. 0.5750 D. 0.7667

Answer: B

Balancing vertical forces gives the normal ground force $N_g = 200\text{ N} + 600\text{ N} = 800\text{ N}$. Taking torques about the base, $N_w(10 \sin 53^\circ) = 200(5 \cos 53^\circ) + 600(6 \cos 53^\circ) = 4600 \cos 53^\circ$, so $N_w = 345\text{ N}$; therefore, the coefficient of static friction is $\mu_s = N_w / N_g = 345 / 800 = 0.4313$.

48. A block of mass 1.6kg is attached to a horizontal spring that has a force constant of 200N/m. The spring is compressed 2.0cm and is then released from rest. At what speed will the block pass through the equilibrium position if a constant friction force of 10.0N retards its motion from the moment it is released? (1)
- A. 75m/s
B. 50m/s
C. 70m/s
D. ✓ 55m/s

Answer: D

— END OF MARKING KEY —

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