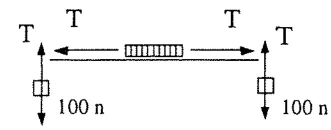
# PHYSICS B
# SOLUTIONS
# SAMPLE EXAM I
# 70 Questions

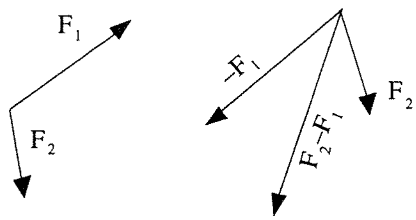
1. (C) 100n



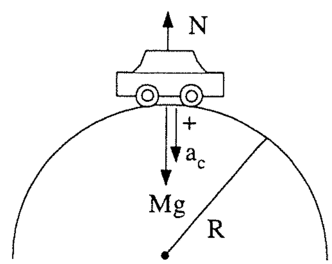

The system is in equilibrium. The tension in each string is the same.
And T = 100 n. ∴ By Newton's 3rd law, the pull is equal and opposite.

2. (D) 

$\vec{F}_2 - \vec{F}_1 = \vec{F}_2 + (-\vec{F}_1)$




3. (C) 30 m/s




Draw a free body diagram for the car on top of the hill

Normal force N = 0. And net $F_c = \frac{Mv^2}{R}$, for circular motion.

$\therefore$ Mg - ~~N~~ = $\frac{Mv^2}{R}$ $\therefore$ $Mg = \frac{Mv^2}{R}$ $\therefore$ $v = \sqrt{Rg}$ $\therefore$ v = 30 m/s

Note: Do not write $F_c$ in the force diagram. You mark $a_c$ which indicates the direction of net $F_c$. Mg and N provide the $F_c$.

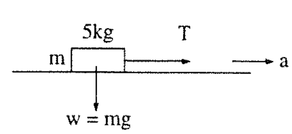
4. (B) Velocity I, Acceleration III

Velocity is the slope of x vs t graph. For the given cosine function of x vs t, $v_A$ is a negative sine curve (slope = 0 at t = 0 and then negative for the 1st quarter cycle). ∴ I is correct. The slope of v vs t graph is acceleration. At t = 0, slope of I is maximum and negative. ∴ Acceleration graph is a negative cosine curve as in III.

5. (D) 3.2 m/s²

The only force that acts on the block in the horizontal direction is the tension which is equal to 16 n.

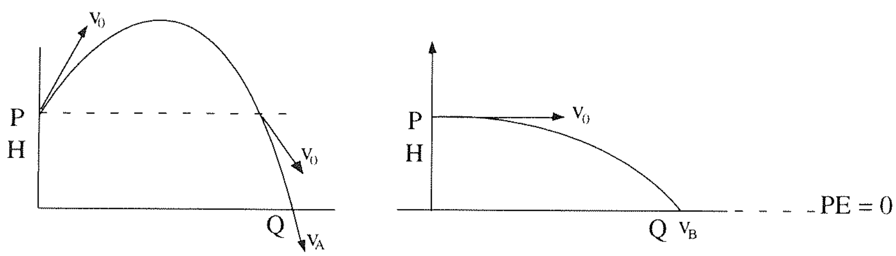
w = 50 n ∴ m = w/g = 5kg. By Newton's 2nd law, Net F = ma.
∴ T = ma ∴ a = 16/5 ∴ a = 3.2 m/s²



6. (D) $v_A = v_B$ and $t_A > t_B$

No external force. ∴ Energy is conserved. ∴ The total mechanical energy at P = The total mechanical energy at Q

For A For B




$\therefore \frac{1}{2}mv_0^2 + mgH = \frac{1}{2}mv_A^2$ $\qquad$ $\frac{1}{2}2mv_0^2 + 2mgH = \frac{1}{2}2mv_B^2$

$v_A^2 = v_0^2 + 2gh$ and $v_B^2 = v_0^2 + 2gh$

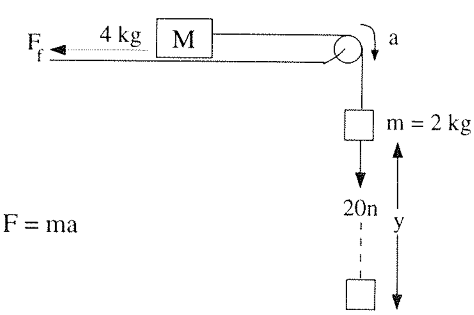
The final velocity is independent of mass. m of A stays in the air longer than the mass 2m of B. ∴ $t_A > t_B$

7. (C) 48J

Use the work-energy principle: W = Δ(KE + PE).
There is a loss of energy due to friction.

The loss in Energy = $mgh - \frac{1}{2}(m + M)v^2 = 48$ J.

OR: use $v^2 = v_0^2 + 2ay$ and get $a = 2/3$ m/s².

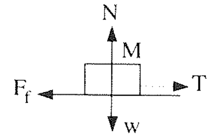



Now use N's 2nd law for the whole system to find the frictional force. Net F = ma
$\therefore 20 - F_f = (m + M)a$ and get frictional force $F_f = 16$ n.
The energy lost by friction = $W = F_f y = 16$ n x 3 m = 48 J.

8. (B) 0.40

Isolate M
$F_f = \mu N$ and because of vertical equilibrium $N = Mg$ ∴ $F_f = \mu Mg$
∴ $W = F_f d = \mu Mgd$ ∴ $\mu Mgd = 48$ ∴ $\mu = 0.4$.

OR: use $F_f = 16$ n and get $F_f = \mu Mg$ ∴ $\mu = \frac{16}{20} = 0.4$



9. (E) $8T_0$

Only the tension T provides the centripetal force $F_c$ on the horizontal table.

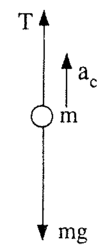
$$\text{Net } F_c = \frac{mv^2}{R} \therefore T_0 = \frac{mv^2}{R} = \frac{mR^2\omega^2}{R}, \text{ (And } v = 2\pi Rf = R\omega) \therefore T_0 = mR\omega^2$$

The new tension $T = m(2R)(4\omega^2) = 8(mR\omega^2) = 8T_0$

10. (D) 3mg upward

Using the law of conservation of energy, first find v at the lowest point. Choose PE = 0 at the lowest point.

$\therefore mgR = \frac{1}{2} mv^2 \therefore v^2 = 2gR$ ...(1)




Now, Net $F_c = \frac{mv^2}{R}$. Show all the forces acting on the mass at the lowest point.

$\therefore T - mg = \frac{mv^2}{R}$ (substitute for $v^2$ from (1))

$\therefore T = 3mg$, upward

11. (B) 20 m/s

The area under the F-t curve is equal to $\Delta\vec{p}$. And $F\Delta t = \Delta p$.
At 40 s total area = 0 (The area above the time axis is positive, that below the time axis is negative.)
$\therefore 0 = mv_f - mv_i$
$\therefore v_f = v_i = 20$ m/s

12. (C) 4000 kg m/s

Also, the area under the F–t curve is impulse I. And $I = F\Delta t = \Delta p$

At 20 s, the area of the triangle $= \frac{1}{2}Ft = I \therefore I = 4{,}000$ kg m/s.

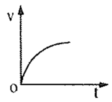
13. (C) Electric potential

Electric potential V = work/charge, and work is a scalar quantity.

14. (C) 10 m/s

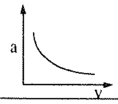
P = 60kW, t = 2 s. Power $= \frac{\text{work}}{\text{time}}$, and work = change in the kinetic energy.

$\therefore W = Pt = \Delta KE \therefore 60{,}000 \times 2 = \frac{1}{2} mv^2 - 0 \therefore v = 10$ m/s

15. (B) 


$W = Pt$ and $W = \Delta KE$

$Pt = \Delta KE = \frac{1}{2} mv^2 - 0 \therefore t \propto v^2$, compare this with $x = y^2$. It's a parabola about t axis.

16. (E) 


Power $P = Fv \therefore P = mav \therefore a \propto 1/v$ ( $\because$ P, m constant)

17. (E) None of them

- The speed is constant, not velocity. The centripetal force changes the direction of motion.
- The acceleration is not zero. The centripetal acceleration $a_c = v^2 / r$

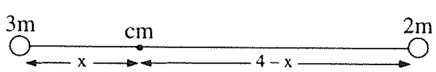
- Net $F \neq 0$. $F_{gr} = GmM/r^2$ which provides the centripetal force $F_c$.

18. (B) Neither its velocity nor its acceleration is zero

On earth $F_{gr} = \frac{GmM_e}{R_e^2} = mg$.

$F_{gr}$ and g are constant and downward on the earth everywhere on the path of the ball.
$F_{gr} = mg$ and $g \approx 10$ m/s$^2$.
At H, Vertical velocity is zero, Horizontal velocity is constant and g is downward.

19. (E) 1.5:1



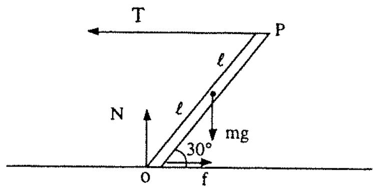

First find the distance x by taking the moment of forces or using the concept of equilibrium about the center of mass.
$3\cancel{m}x = 2\cancel{m}(4 - x) \therefore x = 1.6$ meters.
$F_{gr} = Gm_1m_2 / 4^2$ is equal in magnitude and opposite in direction on each mass which provides the net the centripetal force towards the center of mass cm.

$$\therefore \frac{m_2v_2^2}{r_2} = \frac{m_3v_3^2}{r_3}$$

$$\therefore \frac{2mv_2^2}{(4-x)} = \frac{3mv_3^2}{x} \therefore \frac{v_2^2}{v_3^2} = \frac{3 \times 2.4}{2 \times 1.6} \therefore v_2 / v_3 = 1.5 / 1.0$$

20. (B) 86.6 n

First draw the Force diagram for the beam. Label all the forces on the beam.




All the forces on the beam are shown above. f is the frictional force and N is the normal force on the end of the beam on the table.

The beam is in linear and rotational equilibrium. $\therefore$ Net $\vec{F} = 0$, and Net $\Im_{axis} = 0$.
Take torque about the axis O. Assume $2\ell$ = length of the beam.
$T\,(2\ell)\sin 30 - mg\,(\ell)\cos 30 + f\,(0) + N\,(0) = 0$
$\therefore T = mg\cos 30 \quad \therefore T = (10)(10)(0.866) = 86.6$ n

21. (D) $\sqrt{\frac{kx^2}{m} - 2gh}$

Use the law of conservation of energy.

(1) First find the initial speed at B: $\frac{1}{2}kx^2 = \frac{1}{2}mv_0^2 \therefore v_0^2 = kx^2/m$

(2) Total energy at B = total energy at A $(\because F_{ext} = 0)$

$\therefore \frac{1}{2}mv_0^2 = mgh + \frac{1}{2}mv_A^2 \therefore v_A^2 = v_0^2 - 2gh \therefore v_A = \sqrt{\frac{kx^2}{m} - 2gh}$

(Assume PE at B is zero)

22. (D) I and III only

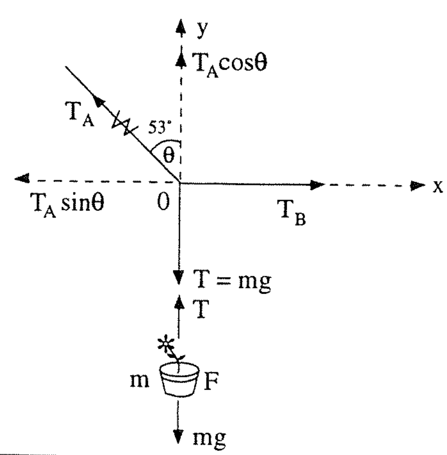
At equilibrium and at position II, $x = 0$, and $F = -kx \therefore F = 0$, $a = 0$ and v is maximum $\therefore$ maximum KE $= \frac{1}{2}mv_{max}^2$

At position I and III, x max = A, F max = –kA and a max = – kA/m and v = 0. $\therefore$ maximum elastic PE $= \frac{1}{2}kA^2$.

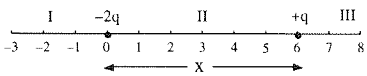
23. (D) $\frac{T_A}{T_B} > 1$

The system is in equilibrium. At equilibrium point O, resolve tension T into vertical and horizontal components.

| Net $F_x = 0$ | and | Net $F_y = o$ |
|---|---|---|
| $\therefore T_A \sin 53° = T_B$ | | $\therefore T_A \cos 53° = mg$ |
| $\therefore T_A\,(0.8) = T_B$ | | $\therefore T_A\,(0.6) = 15$ |
| $\therefore T_A > T_B$ | | $\therefore T_A > 15$ n |



24. (E) II and III only




Net $V = \Sigma \frac{kq}{r}$, where distance r is measured from 0. V is a scalar quantity.

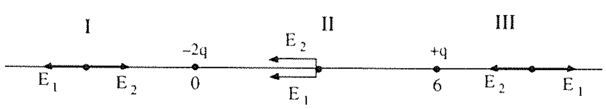
Region I: Electric potential,
$V = -2qk/r + qk/(r + x)$
and $|2q| > q$ and $r < (r + x)$
$\therefore$ V is never zero in region I.

Region II:
$V = -2qk/r + qk/(x-r)$, by intuition and by setting V equal to zero and solving the equation you should get at $r = 2x/3$, for $V = 0$

Region III:
$V = -2qk/r + qk/(r - x)$, by reasoning and solving you should get $V = 0$ at $r = 2x$ .
$\therefore$ V can be zero in regions II and III.

25. (C) III only

Net $\vec{E} = \Sigma \frac{kq}{r^2}$. The directions E–fields due to each charge in each region are shown in the diagram.
E is a vector quantity. Distance r is measured from zero position.




Region I:

$E_2 = \frac{-2kq}{r^2}$, $E_1 = \frac{kq}{(r+x)^2}$

$|E_2| > |E_1|$ $\therefore$ $E_2 > E_1$ $\therefore$ Net $E \neq 0$

Region II:
$E_2$ and $E_1$ are in the same direction $\therefore$ Net $E \neq 0$

Region III:
$E_2$ and $E_1$ are in the opposite direction and Net E may be zero.

OR: Write Net E = 0 and solve for r and check.
$kq/(r-x)^2 - 2qk/r^2 = 0$.

$\therefore \frac{1}{(r^2 - 2rx + x^2)} = \frac{2}{r^2}$

$\therefore r^2 - 4rx + 2x^2 = 0$ has real roots and E = 0 in Region III.
(You may solve the quadratic equation, given x = 6, and convince yourself.)
$r \approx 20.5$ cms in Region III
$r \approx 3.5$ cms < x in Region II, which is not possible

26. (E) $\dfrac{kQ}{R(r+R)}$

The charge flows from X to Y until $V_R = V_r$. Assume that charge q remains on X and ∴ Charge $Q - q$ is transfered to Y.

∴ $kq/R = k(Q-q)/r$ ∴ $qr = QR - qR$ ∴ $q = QR/(r+R)$...(1)

E-field on the surface of X is $E_R = kq/R^2$

$$\therefore E_R = \frac{k}{R^2}\frac{(QR)}{(r+R)}$$

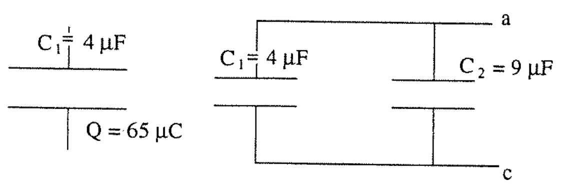
$$\therefore E_R = \frac{kQ}{R(r+R)}$$

27. (C) less than V/I

$R = \dfrac{V_{across}R}{I_{through}R}$. V reads more because of some resistance of the ammeter. Ammeter A reads correct current.

∴ Calculated resistance > the actual R.

28. (B) 45 μC




Total Q = 65 μC. The charge will flow until $V_1 = V_2 = V_{ac}$

$C_1$ and $C_2$ are now connected in parallel. ∴$C_{eff}$ = 13 μF. $\left(\therefore C_{\parallel} = C_1 + C_2\right)$.

$V_{ac} = V_{common} = Q/C_{eff}$ = 65 μC / 13 μF = 5 volts.

∴The charge on $C_2$ : $Q_2 = C_2V$ = 9 μF (5 V) = 45 μC.

OR: $V_1 = V_2$ ∴$Q \propto C$ ∴ 65μC will be distributed proportionally on $C_1$ and $C_2$ in the ratio 4:9.

29. (D) Variation in the speed of a comet around the sun is a consequence of law of conservation of linear momentum

(A) K's loop theorem: Σ(EMF – IR) = 0 and EMF = $\dfrac{\text{work}}{\text{charge}}$

(B) 1st law of thermo: $\Delta Q = \Delta U + \Delta W$

(C) L's law: Work put-in to change the B-flux comes out as the induced EMF

(D) Variation in comet's speed is a consequence of conservation of ANGULAR MOMENTUM,

$$\Delta\vec{L} = 0, \quad \therefore mv_ar_a = mv_br_b$$

(E) K's junction theorem: ΣI = 0, And I = q/t
Flow of charge in = Flow of charge out at the junction in the circuit.

30. (D) III and IV only

The electric vector is perpendicular to the equipotential surfaces and is pointing towards the decreasing potential.

$$\vec{E} = -\frac{\Delta V}{\Delta r}$$

31. (D) 5 times greater.

Circuit A: Series connections: $R_s = 25\ \Omega \therefore I_s = V/R_s = 4$ A

Circuit B: Parallel connection: $R_{\parallel} = \frac{R_1R_2}{R_1 + R_2} = 4\Omega \therefore I_{\parallel} = 25A \therefore I_5 = 20A$

And $I_{20} = 4A$

OR: For parallel circuit; $I_5 = V/R_5$

$\therefore I_5 = \frac{100}{5} = 20A \therefore I_5$ in B = 5 times $I_5$ in A.

32. (E) 6.25 times greater.

Circuit A: $P_A = I^2R_s = 4^2 \times 25 = 400W$ OR: $P_A = \frac{V^2}{R_s} = \frac{100^2}{25} = 400W$.

Circuit B: $P_B = I^2R_{\parallel} = 25^2 \times 4 = 2500W$ OR: $P_B = \frac{V^2}{R_{\parallel}} = \frac{100^2}{4} = 2500W$

$\therefore P_B = 6.25\ P_A$

33. (E) 0.21 A

First find R from 100W, 240V: $P = V^2/R \therefore R = 576$ ohm.
The current in 120 V line, I = V/R = 120/576 = 0.21 A

OR: R = V/I , For constant R, $I \propto V$. With 240 V line,

I = P/V = 100/240 = 0.42 A. $\therefore$ For 120 V line, I = 0.21 A.

34. (A) 4.5U

For capacitors in series connection: $C_s = C_1C_2/(C_1 + C_2) = 2\ \mu F$.

$\therefore U = \frac{1}{2}C_sV^2 = V^2 ...$ (1)

For parallel connection: $C_{\parallel} = C_1 + C_2 = 9\mu F$

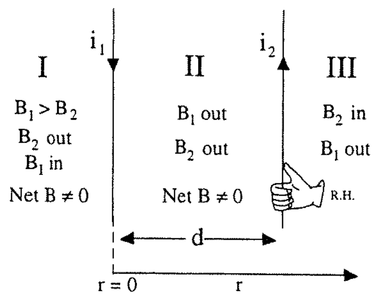
$\therefore U_P = \frac{1}{2}C_{\parallel}V_2 = 4.5V^2 = 4.5U$

35. (B) III only

The force on a charged particle in an uniform E-field is $qE = ma$
$\therefore$ $a = qE/m$, acceleration is constant and velocity v changes.
$\therefore$ Momentum, $p = mv$, changes.

36. (C) III only

Use the Right Hand rule to determine the directions of B-fields in the plane of the paper. $i_1 > i_2$.

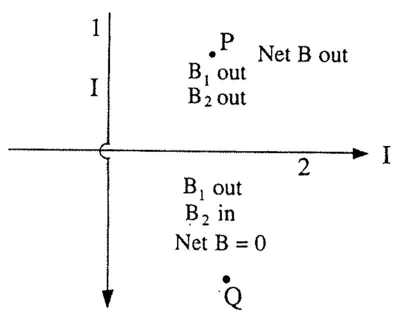



The Right Hand Rule:
Grab the current wire with your right hand so that the thumb points in the direction of the current, the curled fingers point in the direction of the B-field. B-field lines are circular around the wire and are perpendicular to the plane of the paper.

In region III: Net $B = \dfrac{\mu_0 i_1}{2\pi r} - \dfrac{\mu_0 i_2}{2\pi(r-d)}$ can be zero.
In region I: $i_1 > i_2$ and $r_1 < r_2$. $\therefore$ $B_1$ is always greater than $B_2$.

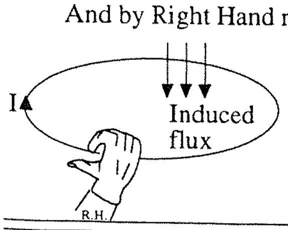
37. (B) At P, non-zero pointing out of paper; At Q, zero

Use the right hand rule to determine the directions of the B-fields at points P and Q.




38. (D) The magnetic flux produced by the induced current in the loop should be pointing into the paper within the loop

$\varepsilon = -N\dfrac{\Delta\Phi_B}{\Delta t} = -N\dfrac{\Delta(BA)}{\Delta t} = -N\dfrac{\Delta}{\Delta t}\left(\dfrac{\mu_0 I}{2\pi r}\right)A$ ($\because$ The magntic field around the current carrying wire is $B = \dfrac{\mu_0 I}{2\pi r}$)
The induced current in the loop depends on the time rate of change of current in the long wire $\therefore$ (A) is wrong.
The induced current in the loop also depends on how fast the current is changing and the area of the loop $\therefore$ (B) is wrong.
By the Right Hand rule the magnetic flux due to the decreasing current I at the position of the loop is into the paper and the flux is decreasing. $\therefore$ (C) is wrong.
By Lenz's law, the induced current in the loop will add the induced flux into the paper within the loop to oppose the inward decrease in the flux due to the decreasing current I in the long wire. $\therefore$ (D) is correct.
And by Right Hand rule the direction of the induced current is clockwise $\therefore$ (E) is wrong.




The Right Hand Rule: Grab the loop with your right hand so that your fingers point towards the direction of the induced flux within the loop (into the paper in this case). The direction of the stretched thumb is the direction of the induced current or emf.

39. (E) $\frac{I^2Rt}{m}$

The energy of the heating coil goes to convert the liquid into a vapor state without changing the temperature.
$\therefore I^2Rt = mL \;\; \therefore L = I^2Rt/m$

40. (E) energy

The work or change in energy = Pt in units of watt-sec.
∴ kWh is the unit of Energy. Efficiency = power in/power out.
EMF has a unit of volts = J/C.
The unit of power is J/s or watt or kW.

41. (B) $1.2 \times 10^7$ m/s

The electron is repelled by the negative plate and accelerates towards the positive plate across the potential difference V.
∴ All of the electrical PE goes to the KE of the electron.
$\therefore eV = \frac{1}{2}mv^2 \;\therefore v = \sqrt{2eV/m} \;\therefore v = 1.2 \times 10^7$ m/s

42. (C) $1.4 \times 10^{16}$ m/s$^2$

The force on the electron is $F = qE$ and $E = V/d$ for uniform electric field.
$qE = ma \;\therefore qV/d = ma \;\therefore a = qV/md$

$$\therefore a = \frac{1.6\times10^{-19}\times400}{9.11\times10^{-31}\times0.005}$$

$$\therefore a = 1.4 \times 10^{16} \text{ m/s}^2$$

OR: use $v^2 = 2ad$, for constant acceleration.

43. (C) $i_3 > i_2$ and $i_1 = 0$

Induced emf $\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$ and induced current $I = \frac{|\varepsilon|}{R}$

$\therefore I = \varepsilon / R = \frac{1}{R}\frac{\Delta(\Phi_B)}{\Delta t} = \frac{1}{R}\frac{\Delta(B_2A)}{\Delta t}$; (R is constant)

In region I: $B = 0$
$\therefore i_1 = 0$, No change in magnetic flux

In region II: $B_2$ is into the paper and changing.
$i_2$ is induced in the conducting loop only by part of the enclosed changing flux of region II.

In region III:
$i_3$ is induced in the conducting loop by all the enclosed changing flux of region II.

$i_3 > i_2$ and $i_1 = 0$.

44. (E) The equipotential surfaces are equally spaced in any electric field for a one volt potential difference.

$\vec{E} = -\frac{\Delta V}{\Delta r}$, For uniform E, equipotential lines are equally spaced. Spacing is $\propto$ l/r around the point charge.
The electric field vector points in the direction of decreasing potential.
The equipotential lines are closer in stronger E-field and farther away from each other in weaker E field for 1 volt potential difference.
Equipotential lines are equidistant in uniform E-field, not in nonuniform E-field.
Work = q$\Delta$V and $\Delta V = 0$ on any equipotential surface.

45. (E) the energy of the wave is directly proportional to the square of the amplitude of the wave

(A) The waves in the string are transverse waves and can be polarized.
(B) The points on the string vibrate perpendicular to the velocity (or propagation) of the wave.
(C) $v = f\lambda \therefore f \propto 1/\lambda$
(D) $v = \sqrt{T/\mu}$ and $\mu$ = M/L = mass/length. T = Tension, v = velocity
(E) The energy $\propto A^2 fv$, where, A = amplitude, f = frequency

46. (B) II and III only

The waves in the string and the E-M radiation waves are transverse, and can be polarized.
The compression waves and standing waves can be sound waves and longitudinal waves cannot be polarized.

47. (B) 387.5 n

$v = f\lambda$. For the fundamental frequency in a given string, $L = \frac{\lambda}{2}$ and L and $\lambda$ are constant.

Also, the velocity of a wave in a string is $v = \sqrt{\frac{T}{\mu}}$, T = tension and $\mu$ = mass/length.

$$\therefore v_2/v_1 = f_2/f_1 \ldots\ldots (1) \text{ and } v_2 / v_1 = \frac{\sqrt{\frac{T_2}{\mu}}}{\sqrt{\frac{T_1}{\mu}}} = \sqrt{T_2 / T_1} \ldots\ldots (2)$$

$$\therefore \sqrt{\frac{T_2}{T_1}} = \frac{f_2}{f_1}$$

$$\therefore T_2 = T_1 \frac{f_2^2}{f_1^2} = 480 \times \frac{4.6^2}{5.12^2}$$

$$\therefore T_2 = 387.5 \text{ n}$$

48. (D) whistle

For fundamental frequency the length of the vibrating element L with one end open must meet the condition $L = \lambda/4$.

For 2 ends fixed in a string or two ends open in a gas pipe, $L = \frac{\lambda}{2}$ for the fundamental frequency.

Only D is correct.

49. (B) II only

I. Normal incident ray does not bend.
II. The velocity (speed or direction or both) changes
III. f, the property of the source, does not change.
$v = f\lambda$. $\therefore$ if v changes, wavelength $\lambda$ changes.

50. (C) light of high frequency is scattered much more than the light with low frequency

The scattering of light $\propto f^4$. The shorter wavelengths of blue-violet rays scattered away and the longer wavelengths of red-yellow rays scatter less and stay in the field of view.

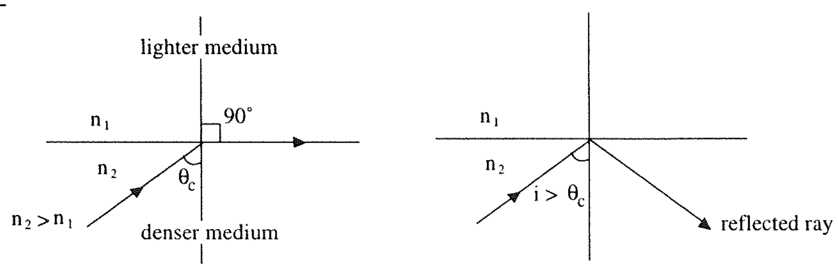
51. (B) greater than 20 cm

When light travels from a denser medium to a lighter medium, it bends away from the normal. Water will converge less and f will increase.

52. (A) a and b only

1. A ray parallel to the principal axis, after refraction passes through the focus or appears passing through the focus of the lens and vice versa.
2. A ray passing through the center of the lens travels unrefracted.
In a diverging lens, the refracted rays on the other side diverge. Rays A and B are drawn incorrectly.

53. (B) II only




For refraction, $\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$. Critical angle $\theta_c$ for the total internal reflection is given by

$$\frac{n_2}{n_1} = \frac{\sin 90}{\sin\theta_c} = \frac{1}{\sin\theta_c} \therefore \sin\theta_c = \frac{n_1}{n_2}.$$

I. For total internal reflection angle of incidence $i > \theta_c$.
II. The angle of refraction is greater than the angle of incidence only when light passes from denser medium to lighter medium and the total internal reflection in the same medium becomes possible.
III. The angle of incidence and angle of refraction can never be in the same medium. Here, the angle of incidence and the angle of reflection are in the denser medium for total internal reflection.

54. (C) a, c and e only

1. When a light ray passes from a lighter medium to a denser medium, light bends towards the normal in the denser medium.
2. When a light ray passes from a denser medium to a lighter medium, light bends away from the normal in the lighter medium.

Lenses a and c are thick at the center and light converges.
Lens e will converge the light. In this concave lens air is inside and glass is outside.
Lenses b and d are thinner at the center and will diverge the light.

55. (E) the work done by the gas is zero

Isothermal process: $\Delta T = 0$ and $PV = \text{constant}$, $P \propto 1/V$
(A) and (C) are correct.
1st law of thermo: $\Delta Q = \Delta U + \Delta W$.

For a monatomic gas, change in the internal energy is, $\Delta U = \frac{3}{2} k \, \Delta T$ and $\Delta T = 0$ $\therefore$ $\Delta U = 0$ $\therefore$ U is constant for isothermal expansion.
$\therefore$ (B) is correct, and $\therefore \Delta Q = \Delta W$ and change in work is positive.
$\therefore$ Work is done by the gas and (E) is wrong.

$\therefore$ Entropy $= \Delta Q / T = \frac{\Delta W}{T}$ increases.

(NOTE: The work done by the gas in the isothermal expansion is $W = nRT \ln\left(\frac{V_f}{V_i}\right)$.
Also, for any thermodynamical process the area under the curve in a PV diagram is work.)

56. (C) Carnot efficency, 72%; Actual efficiency, 66%

Carnot efficiency $= 1 - \frac{T_C}{T_H} = 1 - \frac{300}{1073} = 0.72 \equiv 72\%$

Actual efficiency $= \frac{Q_{in} - Q_{out}}{Q_{in}} = \frac{work_{out}}{Q_{in}} = \frac{250}{380} = 0.66 = 66\%$
(NOTE: Use Temp. in Kelvin.)

57. (D) the temperature of the gas decreases

Adiabatic process: $\Delta Q = 0$, And $\Delta Q = \Delta U + \Delta W$ (1st Law of Thermo)
$\therefore$ $\Delta W = -\Delta U$, In adiabatic compression work is done on the system. $\therefore$ Work is negative.
$-\Delta W = -\Delta U$ $\therefore$ $\Delta W = \Delta U = U_f - U_i$ which is positive.

$\therefore$ U increases and $\Delta U = \frac{3}{2} k\Delta T$ $\therefore$ T increases and (D) is wrong.
(NOTE: In the adiabatic expansion work done by the system is positive, U decreases and $\therefore$ T decreases).

58. (E) Watt-second

When pressure is constant the work done on or by the gas is, $W = P\Delta V$ in Joules which is Watt-sec.

59. (A) 1 atm.

The total pressure $P = P_1 + P_2 + P_3$ .... for the enclosed mixture of gases at a given temperature. The pressure is directly proportional to the number of moles, n, of a gas in the given volume of the mixture.

$n_{He} = \frac{8}{4} = 2$ moles; $n_{Ar} = \frac{20}{40} = \frac{1}{2}$ mole.

For ideal gas:
PV = nRT

$\therefore$ P/n = RT/V = constant $\therefore P \propto n \therefore \frac{P_{Ar}}{P_{He}} = \frac{n_{Ar}}{n_{He}} = \frac{\frac{1}{2}}{2} \therefore \frac{P_{Ar}}{P_{He}} = 1/4$ ..... (1)

And $P_{Ar} + P_{He} = 5$ atm ..... (2)

From (1) and (2) You should get $P_{Ar} = 1$ atm. and $P_{He} = 4$ atm.

60. (E) none of the above

$\Delta V = V_0 \beta \Delta T$.
$\beta_2$ (Rubber) > $\beta_1$ (mercury). $\therefore$ Mercury will not overflow.

OR: The relative increase in the volume of rubber is:

$\Delta V = V_0 (\beta_2 - \beta_1)\, \Delta T = 250 \times 10^{-6}(2.40 - 1.82) \times 10^{-4} \times 30$
$= +0.435\ cm^3$ which is positive.

$\therefore$ The increase in the volume of the rubber the container is greater than that of mercury. $\therefore$ The mercury will not overflow.

61. (E) 0 °C and 0.01 kg ice left

If all 0.06 kg of ice melts at 0 °C, it will need heat $Q = mL = 0.06 \times 3.35 \times 10^5 = 2.01 \times 10^4$ J ..... (1)
0.04 kg of water from 100 °C to 0 °C gives heat
$Q = mc\, \Delta T = 0.04 \times 4.192 \times 10^3 \times 100 = 1.68 \times 10^4$ J ..... (2)
The heat given by water is not enough to melt all the ice. It will melt only nearly 0.05 kg of ice and 0.01 kg of ice will be left over, and the mixture will be at 0 °C.
(NOTE: If you use the method of mixture: Heat loss = Heat gain, you will come up with –8 °C temperature of the mixture, which is not possible.)

62. (D) 31 grams

The # of half lives n = 20 days / 4 days = 5. In 5 half lives, out of 1000 gm, only 31.25 gm will remain undecayed.
OR: Total mass / mass remained undecayed = $2^n$ where n = 5.
The mass left = $1000/2^5 = 31$ gm.

63. (B) 42 km

The length of an object (or distance between two points) measured in the reference frame in which the object is at rest (or two points are at rest) is called its proper length.

$L_0 = 300$ km proper length. $\beta^2 = \frac{v^2}{c^2} = \frac{0.99^2 c^2}{c^2} = 0.98$.

$L = L_0\sqrt{(1-\beta^2)} = 300\sqrt{(1-0.98)} = 300\sqrt{0.02} = 42.4\text{km}$.

64. (D) an electron and an antineutrino

$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e + \bar{\nu}$ (antineutrino)

Mass numbers (proton + neutron) and Z numbers (charges) are conserved.

65. (C) $9.45 \times 10^{-30}$ kg

Mass is converted into energy. 1 u = $1.66 \times 10^{-27}$ kg
931.5 MeV = $1.66 \times 10^{-27}$ kg mass.
∴ 5.30 MeV = $9.45 \times 10^{-30}$ kg mass lost.

66. (B) The stopping potential for a given photocathode increases with the intensity of the striking light

Photocurrent ∝ Light intensity (= # of photons)
$KE_{max} = eV = hf - hf_0$ ∴ $KE_{max} \propto f$. ∴ V = stopping potential ∝ frequency.
∴ stopping potential or $KE_{max}$ does not depend on the intensity of light.

Work function $\Phi = hf_0$ is a characteristic of the photocathode material.

67. (E) $1.50 \times 10^{-23}$ kg m/s

When an electron accelerates across the potential difference, its electric PE is converted into KE.

$$\therefore \; KE = \frac{1}{2}mv^2 = eV$$

$$\therefore v = \sqrt{2eV/m} \; \therefore \text{Momentum } p = mv = \sqrt{2eVm}$$

$$\therefore p = \sqrt{2 \times 1.6 \times 10^{-19} \times 800 \times 9.11 \times 10^{-31}}$$

$$= 1.527 \times 10^{-23} \text{ kg}$$

OR: $KE = eV = p^2/2m \; \therefore p = \sqrt{2meV}.$ or $P = \sqrt{2m.(KE)}$

68. (C) The experiment confirms that the x-rays carry momentum

In Compton's experiment the change in the wavelength, $\lambda_{scattered} - \lambda_{incident}$ is given by,

$\Delta\lambda = \frac{h}{mc}(1 - \cos\phi)$; $\vec{p} = h/\lambda$ = momentum of light photon. $\angle \phi$ = angle of scattered photon.
λ scattered > λ incidence, frequency scattered < frequency incident.
Law of conservation of photon momentum was used by Compton to confirm the experimental result.

$$\frac{\vec{h}}{\lambda} = \frac{\vec{h}}{\lambda'} + \vec{P}_{el}$$

69. (E) Davisson and Germer's experiment

(A) Reveals particle nature of light and work function: $KE_{MAX} = hf - hf_0$.

(B) Reveals particle nature and photon momentum

(C) Is $\Delta x . \Delta p > \frac{h}{4\pi}$ ; position and momentum both cannot be measured simultaneously with the desired maximum accuracy.

(D) Reveals quantization and magnitude of elementary charge.

$Q = ne$ and $e = + 1.6 \times 10^{-19}$ C

(E) Reveals diffraction pattern of electron beam through the crystal and the wave nature of particles.

70. (E) II and III only

The force on the charge in the B-field is $F_B = q\ v \perp B = qvB\sin\theta$.

I. The charge q accelerates only when $v \perp B$ or v makes an angle with B. $a = 0$ if $v = 0$ Or v is parallel to B.

II. In an electric field, $F_e = qE = ma$, the charge always accelerates.

III. Changing B-field changes the speed and the KE of the charge. $qvB = mv^2/R$
or changing B-field induces the E-field which will change the speed of the charge increasing its KE.