ጎንደር የሰላም እና የዕድገት ማኅበር (ጎ-ሰ'ማ)
GONDAR PEACE AND GROWTH ASSOCIATION (GPGA)

በጎንደርና አካባቢው ሀገር አቀፍ የ12ኛ ክፍል መልቀቂያ ፈተና የሚወስዱ ተማሪዎችን በስነልቦናም ሆነ በክህሎት ማዘጋጀትና አጠቃላይ የሥራ፣ ማኅበራዊና ኢኮኖሚያዊ ግንዛቤን የማሳደጊያ ፕሮጀክት

(ከዳሸን ቢራ ፋብሪካ አ.ማ ጋር በመተባበር የቀረበ)

ጎንደር የሰላምና የዕድገት ማኅበር (ጎ-ሰ'ማ) በጎንደር እና አካባቢው ከጊዜ ወደ ጊዜ ሥር እየሰደደ የመጣውን የሰላም እጦት እንዲሁም በአካባቢው ሰፍኖ የሚገኘውን ከፍተኛ ኢኮኖሚያዊ ችግር በመቅረፍ ረገድ መንግሥት የሚያደርገውን ጥረት ለመደገፍ የተቋቋመ እና ከኢፌዴሪ የሲቪል ማኅበረሰብ ድርጅቶች ባለሥልጣን ዕውቅና የተሰጠው (የተመዘገበ) ማኅበር ነው።

ጎንደርና አካባቢው እምቅ የሆኑ በርካታ የተፈጥሮ ፀጋዎችንና ሰው ሠራሽ ሃብቶችን ባለቤት ቢሆንም እነዚህን እምቅ ሃብቶች በጋራ አልምቶ በእጅጉ የወደቀውን ኑሮውን ለማሻሻል አልቻለም። ለዚህም ዋነኛው ምክንያት የማኅበረሰቡ የማኅበራዊና የኢኮኖሚ ግንዛቤ እጥረት መሆኑን በማመን **የጎንደር የሰላምና የዕድገት ማኅበር (ጎ-ሰ'ማ)** አስፈላጊውን የዘርፉ ንቃት ለመፍጠር አቅድ በመንደፍ እየተንቀሳቀሰ ይገኛል።

ከማኅበረሰቡ አካላት መካከልም የዛሬው ትውልድ አካልና የነገ ሀገር ተረካቢ የሆኑት ተማሪዎች ላይ መሥራት፣ ለማኅበረሰቡ ካላቸው ቅርበት አንፃር ከወዲሁ የማኅበረሰባቸውን ኑሮ ለማሻሻል ዓልመው እንዲሰሩና በዚህ ዙሪያ በንቃት እንዲሳተፉ ማድረግ አጠቃላይ ሥራውን የተሳለጠና የሰመረ የሚያደርገው ይሆናል።

በተለይም ከቅርብ ጊዜ ወዲህ የዩኒቨርሲቲ መግቢያ ፈተና እየወሰዱ ማለፍ ያልቻሉ ተማሪዎች ቁጥር እያሻቀበ መምጣቱ በዚህ ደረጃ ያሉትን ተማሪዎች ማንቃትና ማብቃት የተሻለ ነገን ለመፍጠር በር ከፋች መሆኑ እሙን ነው።

ስለሆነም ይህን የማብቃትና የማንቃት ሥራ ጎ-ሰ'ማ፣ ከ2014 ዓ.ም ክረምት ወቅት ጀምሮ በሁሉም የጎንደር ዞኖች ሥር ባሉት ከ 66 በላይ ወረዳዎች ውስጥ በሚገኙና የ12ኛ ክፍል መልቀቂያ ፈተናን ከሚያስፈትኑ 143 ት/ት ቤቶች መካከል በ80ዎቹ ላይ ለመተግበር አልሟል። በመጀመሪያው ዙርም በውጤታቸው የተሻሉ 10,000 (አስር ሺህ) ተማሪዎችን በመመልመል ለፈተናቸው ዝግጁ እያደረገ እግረ መንገዱንም ለማኅበረሰባቸው የተሻለ ሃሳብና ራይዕ ያላቸው ዜጎች እንዲሆኑ በመሥራት ለራሳቸውም ሆነ ለአካባቢው ማኅበረሰብ ሥራ ፈጣሪና ሩቅ አሳቢ፣ ኃላፊነት የሚሸከም ትውልድን ለመፍጠር ይሞክራል።

ይህ ለፊዚክስ ፈተና ማዘጋጃ የተዘጋጀ ሞጁል በዚህ አግባብ የቀረበ ሲሆን በጎ-ሰ'ማ አስተባባሪነት ከሥር ባሉት በጎ ፈቃደኛ ሙያተኞች የተሰናዳ ነው።

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Gondar, Ethiopia

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Unit -1: Review and Summary of Measurement

1.1 Measurements

- The science of measurement is used to reduce uncertainty in measurement ,to increase the precision of measurement ,and to certify the quality of a material .
- Scientific method is a systematic process through observation ,reasoning ,modeling ,and theoretical prediction .
- The steps in scientific method are
  1. Observation ,
  2. Ask question
  3. Do background research
  4. Make a hypothesis
  5. Test your hypothesis by design experiment
  6. Analyze the experimental data
  7. Draw a conclusion
- Significant figures are the number of digits used in a measurement regardless of the location of the decimal point.
- The rules of significant figures are;
  1. All non - zero digits in a number are significant.
     Example: 1426 has four significant figures
  2. All zeros between two non-zero digits are significant
     .Example: 4007 has four significant figures
  3. Zeros used to show the decimal point before a non-zero digit is not significant .
     Example 0.000425 has three significant figures
  4. Zeros at the end without the decimal point (trial zeros) are not significant Example: 2100 may have two or three or four .It must be written in scientific notation.
- The technique of rounding off significant figure during calculation are;
  1) Number greater than 5 can be round off to the preceding digit as 1
  2) Number less than 5 can be round off to the preceding digit as 0
  3) Number 5 can round off to the preceding digit as 1 if the preceding digit is odd and as 0 if the preceding digit is even.
- Uncertainty is the amount of doubt in a measurement but it doesn't mean wrong, and error in a measurement is the uncertainty in a measurement but it does not mean mistake. Error = | true value - measured value|
- The two types of error are random error and systematic error,
- Random error is unpredictable and has no pattern and it occurs by chance and it may be above and below the true value of a measurement .It can be reduced by taking the average of all repeated measurements.
- Systematic error is error that has bias (pattern) in a measurement and, it may be all above or all remain below the true value. It can be reduced by identifying the source of error.
- The sources of error in a measurement are personal error, zeros (instrumental) error, and parallax error.

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- Accuracy is the degree of closeness to the true (accepted) value of a measurement .It is the degree of correctness or how close a measurement is to the true value.
- Precision is the degree of strict exactness of a measurement .It is the degree to which repeated measurement under the same condition gives the same value or it is how close measurements of the same item are each other.
- The significance of a measurement is indicated by the number of significant digits, and it determines the precision of a measurement.
- As the significant figures of a measurement increases then the precision of a measurement also increases.
- The precision of an instrument depends on the smallest scale division of the instrument.
- Accuracy measurement can be a precise measurement but precise measurement cannot be accurate measurement.

1.2 Topic Related question on Unit 1

I. Choose the best answer from the given alternatives.

1. Which one is the first step in the scientific method?

A) Experiment B) observation C) Hypothesis D) Conclusion

Answer: B, observation is the first step in scientific method.

2. Which one of the following statements is not true?

A) Error never be avoided

B) Random error has pattern

C) Systematic error has pattern

D) Random error can be reduced by taking the mean of repeated measurement

Answer: B, random error has no pattern, it occurs randomly

3. How many significant digits does the number 0.001022 have?

A) Two B) four C) six D) seven

Answer: B, since 0.001022 has four significant digits

4. Which one is the source of experimental error?

A) Personal error B) parallax error C) zeros error D) all of the above.

Answer: D, all are the sources of error

5. Which one of the following statements is true?

A) Random error affects the precision of a measurement.

B) Systematic error affects the precision of a measurement.

C) Zeros error is a systematic error D) all of the above.

Answer: D, all statements are true.

6. Which one is the correct rounding off 2.3451 to three significant digits? A) 2.34 B) 2.35 C) 2.345 D) 0.345

Answer: A 2.3451=2.34, since the number before 5 is even (4) therefore 5 cannot round off.

7. A student measures the voltage across the circuit if the current is measured to be 2.21A and the resistance is 0.4, what is the correct value of voltage? A) 0.9V B) 0.88V C) 0.8V D) 0.88V

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Answer: A, since V=I .R =(2.21)x(0.4)=0.884 V is correctly written to the least significant digit i.e. two digit so V=0.9V

8. A teacher measures the amount of electric current as I=2.2A ± 0.1, what is the percentage of error? A) 4.58% B) 5.4% B)4% D)5.8%

Answer: A, %error = (Error/T.V)x100=(0.1/2.2)x100=4.58%

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Unit -2: Review and Summary of Vector Quantity

2.1 Scalar and Vector Quantity

- Physical quantity can be classified as basic and derived physical quantity.
- Basic (fundamental) physical quantities are mass, length, time, temperature, electric current, amount of substance, and luminous intensity.
- Basic -SI units are kilogram, meter, second, kelvin, Ampere, mole, candela.
- Physical quantity can also classify as vector and scalar physical quantity.
- Vector physical quantity have both magnitude and direction,
  Examples: displacement, velocity, acceleration, force, momentum, impulse... it can have a negative meaning in the opposite direction.
- Scalar physical quantity have only magnitude (dimension),it can't be negative
- Vectors can be represented graphically and symbolically.
- Types of vectors are position vector, unit vector, collinear vector, coplanar vector, orthogonal vector.
- A unit vector is a vector that has a magnitude of one unit, and it is used to show the direction of a given vector. Example : i , j ,k
- Collinear vectors are vectors that exist along the same line, and they may be parallel or opposite to each other.
- Coplanar vectors are vectors that act on the same plan, and they may be parallel, opposite or perpendicular to each other .
- Orthogonal vectors are vectors that are perpendicular to each other.
- Resolving a vector is the process of finding the components of a vector.
- Component of a vector is the projection of the vector on an axis.
- Vector addition is commutative and associative but vector subtraction is not commutative and associative.
- Vectors can be added by geographical method and component method.
- The unit vector of a given vector can be determined by dividing the vector by its magnitude.
- The projection of vector-A onto vector -B is given by $A\cos\theta$
- If two vectors are equal then they must have the same magnitude and the same direction.
- Scalar (dot) product is the product of two vectors that gives a scalar. It is expressed by
  $A.B = |A||B|.\cos\theta = A_xB_x + A_yB_y + A_zB_z$
- Properties of scalar product ; $A.A=A^2$, A.B =B.A , i.i= j.j = k.k=1, and i.j= j.k = k.i=0
- Vector (cross) product is the product of two vectors that gives another vector.
  $AxB = |A||B|\sin\theta.n = (A_yB_z-A_zB_y)i - (A_xB_z - A_zB_x)\ j + (A_xB_y - A_yB_x)k$
- Properties of vector product are AxA=0 ,AxB= -BxA , ixi =jxj =kxk=0 , ixj=jxk=kxi=1
- The scalar product of two orthogonal vectors is always zero ,and the vector product of two collinear vectors are always zero.

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2.2 Topic Related Questions on Unit 2

I. Choose the best answer from the given alternative

1. Which one of the following is a vector physical quantity?
A) Momentum B) energy C) time D) temperature
Answer: A, momentum is a vector physical quantity

2. Which one is not a fundamental physical quantity?
A) mass B) time C) speed D) temperature
Answer: C , speed is derived physical quantity

3. Let A= mi +2j +k, and B= i +j +3k, what is the value of 'm' such that A and B are orthogonal to each other? A) -7 B)7 C)4 D)3
Answer: A, for orthogonal vectors , A.B= m+4+3=0, m= -7

4. At what angle between vector -A and B such that |A.B| = |AxB|? A) 30^0 B) 45^0 C) 60^0 D) 90^0

Answer: B, AB cosθ = AB sinθ ,→ tanθ=1 , $\theta=45^0$

5. Which one of the following is not correct?
A) A.A =A^2 B) AxA =0 C) AxB =BxA D) A.B =B.A
Answer: C, cross product is not commutative.

6. Let A+2B =i -2j +2k, and 3A-B = 2i +3j -k, what is vector -A?
A) 5i +4j B) 1/7(5i +4j) C) 4i +5j D) 1/7(4i +5j)
Answer: B, since (A+2B) + (3A-B)= 1/7(5i +4j)

7. What is a vector perpendicular to both vector-A = 2i+3j -k, and B= i -2j +2k?
A) 4i +5j+ 7k B) 4i -5j -7k C) -4i -5j -7k D) 4i +4j -k
Answer: B, let C is a vector perpendicular to both vector -A and B then, C = A x B = 4i-5j -7k

8. The sum and difference of two non- zero vectors -A and B are equal in magnitude .what can you conclude about those two vectors?
A) A and B have the same direction B) A and B have opposite direction
C) A and B are perpendicular to each other D) Vector -A greater than vector-B
Answer: C, since |A+B| =|A-B|
, $A^2+B^2+2AB\cos\theta = A^2 + B^2 - 2AB\cos\theta$; $4\cos\theta=0$, $\theta=90^0$.

9. If A = 8i +j -2k and B = 5i -3j +k ,then what is the value of AxB ?
A)3i +4j -3k B) -3i -4j+ 3k
C) -5i -18j -29k D) 5i +18j +29k
Answer: C, using determinant matrix

10. What is the unit vector of A =2i +2j +k?
A) 1/3(2i +2j+k) B) i+ j+ k C) 1/3(i +j+k) D) i -j-k
Answer: A, since Unit vector of A is given by vector,-A divided by its magnitude

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Unit -3: Review and Summary on Kinematics

3.1 Kinematics

- Mechanics is a branch of physics that deals with the motion of a body in general.
- Motion is the relative change in position of a body with respect to a given frame of reference.
- Frame of reference is a rigid body (coordinate system) that is used to describe the motion of a body, and there are two types of frame of reference as inertial and non-inertial frame of reference.
- Inertial frame of reference is a reference frame that is either at rest or moving with constant velocity.
- Motion can be classified as uniform motion and uniform acceleration motion.
- Kinematics is a mechanics that deals with the motion of a body without the causes of motion (force).
- uniform motion is a motion in which a body moves with constant velocity (zero acceleration).
- In uniform motion, the slope of the distance -time graph is equal to speed ,and the area under velocity -time graph is equal to the total distance traveled .
- Distance is the longest length of a journey, and it is a scalar physical quantity measured in SI -unit meter.
- Displacement is the shortest path length of a journey, and it is a vector physical quantity measured in SI -unit meter.
- Uniform acceleration motion is a motion in which a body moving with constant acceleration
- Acceleration is the rate of change of velocity a body it is a vector physical quantity measured in SI-unit m/s2
- Velocity is the rate of change of displacement, and it is a vector physical quantity measured in SI -unit m/s.
- Instantaneous velocity is the velocity at a particular instant of time ,and it is the first derivative of displacement at that time
- Instantaneous acceleration is the acceleration of at a particular time, and it is the second -derivative of velocity at that time.
- In uniform acceleration motion, the slope of the velocity -time graph is equal to acceleration, and the area under acceleration -time graph equal to the change in velocity.
- Deceleration (retardation) is the negative of acceleration in which the velocity of a body decreases with time.
- Freely falling motion is a special kind of uniform acceleration motion in which an object accelerates due to gravity, and in this case, we assume that air -resistance is negligible.
- When a body is start moving from rest then its initial velocity is zero
- When a body is dropped (released) from a certain height then its initial velocity is zero.
- Projectile motion is a two-dimensional (plan) motion in which a body moves horizontally with constant velocity (uniform motion) ,and vertically with constant acceleration (uniform acceleration motion) simultaneously .
- The vertical and horizontal components of a projectile motion are always independent of each other, and the only force acting on a projectile is force of gravity.

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- Range of a projectile is the maximum horizontal displacement of a projectile, and it is maximum at an angle of 45^0.
- Trajectory is the path followed by a projectile and it is a downward parabola.
- Circular motion is a two- dimensional (plane) motion in which a body moves in a circular path.
- There are two types of circular motion as horizontal circular motion and vertical circular motion.
- Horizontal circular motion is a uniform circular motion but vertical circular motion is not uniform circular motion.
- Uniform circular motion is a motion in which the speed of a body remains constant.
- Centripetal (radial) acceleration is an acceleration that arises due to the change in the direction of the tangential velocity, and it is always directed towards the center of the circular motion.
- Tangential acceleration is an acceleration that arises due to the change in the magnitude of the tangential velocity, and it is always tangent to the circular motion.
- In vertical circular motion, the speed at the top of the circular path is minimum but the speed at the bottom of the circular path is maximum.
- For vertical circular motion of a body, the maximum speed is equal to the square root of five times the minimum speed.
- A satellite is a body moving in an orbit around a planet, and there are two types of satellite: natural satellite, and artificial satellite .
- The motion of a satellite is due to the gravitational force of attraction between the satellite and the planet.
- Escaping velocity is the minimum speed with which a body must be launched in order to escape from the gravitational pull of the planet.
- The Escape velocity of a body from the surface of a planet is independent of its mass but it depends on the mass of the planet.
- The escaping velocity a body from different planet is different ,for earth planet ,it is 11.2km/s
- Orbital velocity of a satellite is the horizontal velocity that is given to a satellite at the determined height that makes a satellite around a planet in a circular orbit.
- Orbital velocity of a satellite is independent of the mass of the satellite.

3.2 Topic Related Questions on Unit 3

I. Choose the best answer from the given alternatives?

1. Which one of the following statements is not true?

A) In uniform motion, acceleration is zero

B) In uniform acceleration motion, velocity is constant

C) In uniform motion, velocity is constant

D) In uniform acceleration motion, acceleration is constant

Answer: B, velocity is not constant in uniform acceleration motion.

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2. In a uniform circular motion,_____remains constant .

A) Speed B) velocity C) centripetal acceleration D) tangential acceleration

Answer: A , only speed is constant in uniform circular motion.

3. A car is moving from rest with a uniform acceleration of $4m/s^2$, what is the velocity of the car after 2 second ? A) 8m/s B) 4m/s C) zero D) 16 m/s

Answer: A , since $V= u + a.t$ but u=0, and $V= a.t =(4m/s^2)(2s)=8m/s$

4. A ball is dropped from a building hit the ground after 2-second, what is the height of the building? Use $g=10 m/s^2$ A) 40m B) 20m C) 30m D) 50m

Answer : B ,since, $h = u + 1/2\ gt^2$,but u=0(dropped),$h =1/2(10m/s^2)(2s)^2 =40m$

5. A car starts moving from rest with a constant acceleration of 3 m/s^2, what is the distance traveled at 4^{th} -second? A) 21m B) 10.5m C) 12m D)16m

Answer :B , $S_nth = Vo +a\ (n-1/2)$ but $V_o =0$ (from rest) , $S= 3m/s^2(4-1/2)=21/2=10.5m$

6. The motion of a body is described by the equation; X(t)= 8t +2t2 ,where X is in meters ,and t is in second .What is the velocity at t= 2 second ?

A)16m/s B) 8m/s C) 2m/s D) 10m/s

Answer :A since , $V(t) = X(t)' =(8t +2t2)'= 8+4t$,but at t=2 sec. $V(2)= 8+4(2)=16m/s$

7. The speed of the ball at the top of a vertical circular motion is 4m/s, what is the maximum speed of the body?

A) $4\sqrt{5}$ m/s B) $2\sqrt{5}$ m/s C) $\sqrt{5}$ m/s D) 5m/s

Answer : A , $V_{max} = \sqrt{5}$ $V_{min} = 4\sqrt{5}$ m/s

8. A ball is projected with an initial velocity $-V_o = (20i +10j)m/s$, what is the position of the ball after 1 second ? use $g=10m/s^2$.

A) (20m, 5m) B) (15m, 20m) C) (10m,15m) D) (15m, 10m)

Answer :A , since $V_o=V_{ox}\ i +V_{oy}\ j =(20i +10j)$; $V_{ox} =20m/s$ and $V_{oy} =10m/s$, therefore

$X =V_{ox}.t = 20m/s\ (1s) =20m$ and $Y=V_{oy}.t -1/2g.t^2 = 10m/s(1s)-1/2(10m/s^2)(1s)^2 =5m$

; the position of the ball is (X,Y)= (20m, 5m)

9. An airplane drops a payload while traveling due to North parallel to the ground at constant speed of 100m/s. If air resistance is negligible, what is the velocity of the payload relative to the pane 4 second after it is released? use

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g=10m/s2 A) zero B) 40m/s down

C) 100m/s North , and 40m/s down D)100m/s South and 40m/s down

Answer: B , the velocity of the payload relative to the plan is given by

$V_y = V_{oy} + g.t$ but $V_{oy} = 0$ (drops) , therefor $V_y = g.t = 10m/s2(4s) = 40m/s$ down.

10. An airplane drops a payload while traveling due to North parallel to the ground at constant speed of 100 m/s. if air resistance is negligible , what is the velocity of the payload relative to the plane 4 seconds after it is released ? Use g =10m/s²

A) Zero B) 40m/s down C) 100m/s North and 40 m/s down D) 40m/s North

Answer :B , the relative velocity of the payload with respect to airplane is determined by

$V_y = V_{oy} + g.t$ but $V_{oy} = 0$ (drops) , $V_y = g.t = (10m/s2 \text{ down})(4s) = 40m/s$ down.

Unit -4 : Review and Summary of Dynamics

4.1 Short notes on Dynamics

- Dynamics is a mechanics that deals with motion with the effects of force on it.
- Force is the action of pulling or pushing ,and it is a vector physical quantity measure in SI-unit called Newton
- The four fundamental forces in nature (universe) are strong -nuclear force ,weak-nuclear force ,electromagnetic force ,and gravitational force
- The effects of force are changing the velocity and deforming the shape of a body.
- Newton's first law of motion(the law of inertia) states that "without any external force acting on a body, when a body is at rest it will remain at rest, when a body is in motion ,it will continue in motion with constant velocity".
- Inertia is the property of an object to resist any change on its state of motion, and it depends on the mass of the body, and a body of large mass have large inertia
- Newton's second law of motion states that "the acceleration of a body is directly proportional to the net force acting on the body but inversely proportional to the mass of the body".
- Newton's third law of motion (the law of action and reaction) states that " for every action force ,there is always an equal and opposite reaction force."
- action and reaction forces are always exist in pairs ,they never cancel out each other because they are acting from two different bodies
- Force can be classified as contact and non-contact force; frictional force is an example of contact force, and gravitational force, electromagnetic force are examples; non- contact force.
- Force can also be classified as conservative and non- conservative force, friction is non-conservative force, whereas gravitational force is conservative force.
- Friction is a force that always acting in opposite direction to the motion of an object ,and it dissipate the

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energy of a body(system)

- Friction can never be avoided but it can be reduced by using lubricant oil, and polishing the surface .
- Types of friction are static friction, kinetic friction, and rolling friction.
- Static friction is a friction that exists just before the body is sliding.
- Kinetic friction is a friction that exists when a body is in motion.
- Static friction is always greater than kinetic friction.
- The factors which affect frictional force between two interacting surfaces are the normal force between the interacting surface and the nature of the interacting surface (μ)
- linear momentum is the product of the mass and velocity ,and it is,a vector physical quantity measured in SI -unit kg.m/s
- The net force acting on a body is also defined as the rate of change of linear momentum of that body.
- Impulse of force is the product of the force, and the duration of time of acting ,and it is also the change in linear momentum , impulse is a vector physical quantity .
- The law of conservation of linear momentum states that "For a closed system, the total linear momentum of that system always remains constant.
- Momentum always conserved during collision and explosion.
- The two types of collision are elastic collision and inelastic collision.
- For elastic collision ,both momentum and kinetic energy are conserved
- For inelastic (stick on) collision , only momentum is conserved but not kinetic energy conserved ,and after collision they have common velocity .
- Center of mass is a point at which all the distribution of mass of a body is assumed to be located .
- Center of gravity is a point in a body at which the force of gravity acts .
- Center of mass of a body is not always the center of gravity .
- When a car is moving along a level curved road ,then the centripetal force on the car is balanced by the friction between the road and the wheel of the car , and the maximum speed is given by V = $\sqrt{\mu Rg}$
- When a car is moving along a banked curve road ,then the centripetal force on the car is provided by the components of the normal force on the car ,and its maximum speed is given by V= $\sqrt{rg\tan\theta}$
- Newton's second law for a variable mass system is applicable on rocket propulsion and rain drop.

4.2 Topic Related Questions on Unit 4

I. Choose the best answer from the given alternatives.

1. Which one is the strongest force in nature?

A) Strong nuclear force B) weak nuclear force

C) Electromagnetic force D) gravitational force

Answer: A , strong nuclear force is the strongest and short range force.

2. Which one is an example of contact force?

A) Gravitational force B) frictional force

C) Magnetic force D) electric force

Answer: B , frictional force is a contact force ,it requires the physical contact of the two bodies.

3. Which one is not a true statement?

A) Momentum is conserved in both elastic and inelastic collisions.

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B) Kinetic energy is conserved only for elastic collision.

C) Kinetic energy is conserved during an inelastic collision

D) Impulse equal to the change in momentum

Answer:C , kinetic energy is not conserved during inelastic collision .

4. An object slid down with an inclined plane which makes370 to the horizontal at constant velocity .what is the coefficient of friction between the block and the surface? Use

Cos37^0 =0.8 & Sin 37^0 =0.6

A) 0.1 B) 0.25 C) 0.75 D) 0.5

Answer: C , since the acceleration of the block is zero (constant velocity) ; mg(sinθ - μ cosθ) = ma =0 , μ = tanθ= tan37^0 =0.75

5. A driver moving a car at constant speed of 20m/s sees an accident up ahead and hits the brakes .If the car decelerates at constant rate of 5m/s2 .How far does the car go before it comes to a stop?

A) 40m B) 20m C) 100m D)120m

Answer : A, since V = Vo +a.t but a =-5m/s2 , V=0, so t=4s ,therefore ,

S = Vo.t + 1/2 a.t2 = 20m/s(4s) -1/2(5m/s2)(4s)2 = 80m- 40m= 40m

6. Which one is not true about action and reaction forces?

A) They act up on the same body.

B) They never cancel out each other.

C) They are equal and opposite.

D) They act up on two different bodies.

Answer;A, since the two forces never act on the same body

7. A man standing on a frictionless surface continuously fired 120 bullets horizontally in 1-minute using a machine gun. if each bullet has a mass of 10g ,and leave the muzzle of the gun with a speed of 800 m/s . What is the average force exerted by the gun on the man?

A) 16N B) 8N C) 960N D) 16,000N

Answer :A , F =n(m.V)/t ,but n=120 ,t =1 minute (60s) , V =800m/s ,m= 0.01kg , therefore, F =16N

8. A satellite moves at a constant speed in a circular orbit about the center of the earth at altitude half the radius of the earth above its surface .If g is the gravitational acceleration of the earth, and R is the radius of the earth ,then what is the orbital speed of the satellite ?

A) $\sqrt{3Rg/2}$ B) $\sqrt{2Rg}$ C) Rg D) 2R.g/3

Answer : A , Vo = $\sqrt{R.g}$ but r = R+h ,and h=1/2 R, r =3R/2 ,therefore Vo = $\sqrt{3Rg/2}$

9. A spaceship moving at 1000m/s releases a satellite of 100kg at a speed of 10,000m/s . What is the mass of the spaceship if it slows down to a velocity of 910m/s ?

A) 11,250 kg B) 10,420 kg C) 12,000kg D) 11,800kg

Answer : A , Since, using conservation of linear momentum for inelastic collision,

(M +m)V = M.v + m.u , (M+100kg) (1000m/s) = M(910kg) + (1000kg)(10,000m/s) ; M = 11,250 kg.

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10. A car is moving along a banked curve road of angle 45^0 with radius of 100m, what is the maximum

speed of the car? (Use $\sin 45^0 = \cos 45^0 = 0.707$, $g = 10 m/s^2$)

A)10m/s B)31.6m /s C)18.4 m/s D)20m/s

Answer :B , Since the maximum speed of a car along a banked curve road of angle -θ is given by $V = r.g.\tan\theta = (100m)(10m/s2)(\tan 450)$; V=31.6 m/s

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Unit -5 : Review and Summary of WORKDONE AND ROTATIONAL MOTION

5.1 *Short notes on Work done and rotational motion*

- **Energy** is the crown for physics. It is found in every branch of physics. It is defined as the capacity of a physical system to perform work. And it exists in several forms such as kinetic, potential, thermal, chemical and other forms. And its SI unit is joule (J).
- **Kinetic energy (KE)** is the capacity of an object to do work by virtue of its motion. For an object of mass m and moving with speed v, the kinetic energy is calculated as: $\frac{1}{2}mv^2$.
- When objects are rolling we use both the rotational kinetic energy and translational kinetic energy .

- **Potential Energy (PE)** is the energy that is stored in an object due to its position relative to some zero position.
- An object possesses gravitational potential energy if it is positioned at a height above (or below) the zero height.
- The potential energy concept can be used only when dealing with a special class of forces called *conservative forces*.
- If the work is done on a system, the work done appears as an increase in the energy of the system.
- Power is defined as the time rate of energy transfer.
- If an external force is applied to an object (which we assume acts as a particle), and if the work done by this force in the time interval Δt is W, then the average power during this interval is defined as p=wt . In general, power is defined for any type of energy transfer. depending on the type of collision.
- Whether or not kinetic energy is conserved is used to classify collisions as either *elastic* or *inelastic*.
- **Elastic collision**: - An elastic collision between two objects is one in which the total kinetic energy as well as total momentum of the system is conserved.
- *Perfectly* elastic collisions occur between atomic and subatomic particles.

- Consider two particles of masses m_1 and m_2 moving with initial velocity and along the same straight line, as shown in the figure below.
- The two particles collide head-on and then leave the collision site with different velocities,

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and . If the collision is elastic, both the momentum and kinetic energy of the system are conserved.

- **Inelastic Collision**: - An inelastic collision is one in which the total kinetic energy of the system is not conserved. But the momentum of the system is conserved. Therefore, for inelastic collision of two particles.
- **Perfectly Inelastic Collision**: -When the colliding objects stick together after the collision, the collision is called perfectly inelastic. Consider two particles of masses

Unit -6: Review and Summary of *Fluid Dynamics*

6.1 *Short notes on* Fluid dynamics

- We can describe the elastic properties of a substance using the concepts of stress and strain.
- Stress is a quantity proportional to the force producing a deformation; strain is a measure of the degree of deformation.
- Strain is proportional to stress, and the constant of proportionality is the elastic modulus: We can describe the elastic properties of a substance using the concepts of stress and strain
- .Stress is a quantity proportional to the force producing a deformation; strain is a measure of the degree of deformation.
- Strain is proportional to stress, and the constant of proportionality is the elastic modulus.

  Elastic modulus = $\frac{stress}{\text{[illegible]}}$
- Three common types of deformation are represented by (1) the resistance of a solid to elongation under a load, characterized by Young's modulus Y; (2) the resistance of a solid to the motion of internal planes sliding past each other, characterized by the shear modulus S; and (3) the resistance of a solid or fluid to a volume change, characterized by the bulk modulus B.
- The pressure P in a fluid is the force per unit area exerted by the fluid on a surface:
  $P=F/A$
- The pressure in a fluid at rest varies with depth h in the fluid according to the expression
  $P=p_o+\varrho gh$ Where the expression p_o is the pressure at $h= 0$ and ϱ is the density of the fluid.

- Pascal's law states that when pressure is applied to an enclosed fluid, the pressure is transmitted undiminished to every point in the fluid and to every point on the walls of the container.
- When an object is partially or fully submerged in a fluid, the fluid exerts on the object an upward force called the buoyant force. According to Archimedes's principle, the magnitude of the buoyant force is equal to the weight of the fluid displaced by the object:
  $Fb= \varrho fgv$

Two important concepts regarding ideal fluid flow through a pipe of non-uniform size are as follows:

- The flow rate (volume flux) through the pipe is constant; this is equivalent to stating that the product of the cross-sectional area A and the speed v at any point is a constant. This result is expressed in the equation of continuity for fluids:
  $A1v1=A2v2$

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- The sum of the pressure, kinetic energy per unit volume, and gravitational potential energy per unit volume has the same value at all points along a streamline. This result is summarized in Bernoulli's equation:

  $P1+1/2\varrho v^2+\varrho g h_1 = p_2+1/2\varrho v^2+\varrho g h_2$

6.2 Topics Related Questions on Unit 5 and 6

I Choose the best answer from the given alternatives.

1. A body of mass *5kg falls from a building 40m high . what is the kinetic energy of the body when it is at height of 10m* above the ground A) 2000J **B**) 1500J C) 5000J D) 1000J
Answer B HINT BY USING LAW OF CONSERVATION OF ENERGY

2. When an object is thrown vertically upward it rises to a maximum height of 30m .How high is the object when it has lost one –third of its original kinetic energy ?
A) 10m B) 25m **C)** 10m D) 15m
Answer C , hint 1/3EK = EP

3. The force constant of the spring is 80 N/m and the mass of the body attached to aspring is 5kg the body is initially at rest and the spring is initially unscratched .if the spring is stretched by a constant force of 50N .What will be the speed of the body when it has moved 1m (neglecting friction)
A) 2m/s B) 3m/s C) 2.8m/s D) 1m/s
Answer A, work done= CHANGE OF EK +CHANGE OF EP

4. A car of mass 1000kg is traveling at a speed of 20m/s on a horizontal surface . If the car comes to rest after traveling 50m distance what force of friction tends to stop it .
A)2000N **B)** 4000N C) 5000N D) 1500N
Answer B , hint $\Delta = unbalanced\ force$

5. A300kg object is lifted by a motor with a constant speed of 2m/s. What power is developed by a motor ?
A) 6000W B) 80000W C) 3500W D) 1000W

Answer A P=FV

6. A50kg object is moving under the action of a force along a horizontal floor at a constant speed of 4m/s .If the coefficient of sliding friction is 0.5 what is the rate of work done by the force

A) 2000W **B)** 1000W C) 5000W D) 2500W

Answer B HINT P=FV

7---------- is the ability of a body to do work because of its position

A) Mechanical energy **B)** potential energy C) Kinetic energy D) Heat energy
Answer B

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8. If the frictional force is neglected then $\Delta PE + \Delta KE$ *is* ----------

A) Constant B) increase C) decrease D) unknown

Answer A

9. If the kinetic energy of a moving body remains constant one of the following is not true

A) The work done by the net force is zero

B) The velocity of the body is constant

C) The acceleration is not zero

D) The net force acting on the body is zero

Answer C

10. How much should the spring of the above example be stretched if its elastic potential energy is to be 1.250 J ? A) 70m B) 0.5m **C**) 0.071m D) 0.006m

Answer C

11. A ball of mass 200kg is released from the top of a building 5m above the ground . what is its potential energy when it has fallen half way down ? A)5J B) 8J C)10J **D**) 2.5J

12. from question no 11. How much is its total mechanical energy when it just touches the ground A)

5J **B**) 10J C) D) 2.5J

Answer B

13.---------- is the measure of the ability of a force to rotate a body about some axis

A) Momentum **B)** Torque C) Force D) Force

Answer B

14. It takes 8 seconds for a30kg girl to climb a9 m high flight of stairs . How much is the power developed ? **A)** 337.5 W B) 222.5 W C) 445.5 W D) 155.5W

Answer A

15. A2500kg truck takes 40min to climb from an elevation of 1800m to 2900m along mountain road . What average horsepower does the truck expend against gravity ?

A) 153.6 hp B) 233.3hp C) 166.3hp D) 334.4 hp

Answer A

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16. What is the physical meaning of energy

A) The rate of doing work **B)** The ability of doing work C) Rate of position D)All

Answer B

17. A Pair of two equal and opposite forces with parallel lines of action acting on a rigid body is called --- A) Torque **B)** Couple C) force D) Equilibrium

Answer B

18. The point where the total weight of a rigid body is considered to be concentrated is called A)

Couple **B**) center of gravity C) Torque D) equilibrium

Answer B

19. ---------- is a type of equilibrium where the rigid body moves very far away from its initial equilibrium position due to small displacing force

A) Stable **B)** unstable C) neutral D) all

Answer B

20. One rad is always equivalent to --- A) 90 degree B) 360 degree **C)** 57.3 degree D) 180 degree

Answer C

21. A wheel starts from rest and attains a rotational velocity of 1500rad/sec in 2 minutes. What is its average angular acceleration ? A) 62.5 rad/sec^2 B) 25.5 rad/sec^2 **C**) 12.5 rad /sec^2 D) 10.5 rad/sec^2

Answer C

22. The cycle wheel rotates with a constant angular acceleration of 3rad /sec^2 .I f the initial angular speed of the wheel is 2rad/sec . through what angle does the wheel rotate in 4sec

A) 24 rad B) 52rad **C**) 32 rad D) 40rad

Answer C

23. What is the angular speed at 4 sec for question no 22.

A) 14rad/sec B) 24 rad /sec C) 42rad/sec D) 4 rad /sec

Answer A

24. What is the average angular speed during this time increase between t=0 to t= 4sec from question no 22. A) 10rad/sec B) 18rad/sec **C**) 8rad/sec D) 4rad /sec

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Answer C

25. The centripetal acceleration is always directed toward to --------

A) upward B) out of the center **C**) toward to the center D) tangent to the circle

Answer C

26. The work done by the centripetal force is ------- A) maximum B) minimum **C**) zero D) negative
Answer C

27. What constant torque must be applied to a uniform solid cylinder having amass of 1kg and radius of 10cm to increase the angular velocity of $40\pi rad/\sec$ in 10 sec (use $I=\frac{1}{2}Mr^2$)

A) 0.89 Nm B) 0.089 Nm **C)** 0.0628Nm D) 0.0789Nm

Answer C

28. A2kg ball having radius of 0.2m is rotated with an angular velocity of 20rad/sec about an axis along ay of its diameter .What is the rotational kinetic energy (use $I=\frac{2}{5}Mr^2$)

A) 64J B) 34J **C**) 6.4J D) 9.4J

29. From question no 28 what is the angular momentum

A) 0.64kg m^2/s B)) 64kg m^2/s C) 6 .4kg m^2/s D)) 4kg m^2/s

Answer A

30. A5kg ball having radius of 0.3m initially at rest rolls with a linear speed of 4m/s . what is the kinetic energy of the ball ? A) 5J B) 10J C) 64J **D**) 56 J
Answer D

31.Asubstance has a relative density of 1.5 . What is the volume of substance if its mass is 30kg A)

200m^3 B) 2.500m^3 **C**).002m^3 D) 0.02m^3

Answer C

32. What is the pressure at depth of 20m in lake water (take density of water 1000kg/m^3)

A) $3.01x10^5$ pa B) $2x10^5$ pa C) $3.3x10^5$ pa D) $1.01x10^5$ pa

ANSWER A

33.At what depth of sea water is the pressure equal to $6.01x10^5$ pa

A) 100m **B)** 50m C) 25m D) 10m

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Answer B

34. The volume of a cube is 8cm ^{3} .What is the buoyant force on it when it is completely submerged in water of density 1000kg /m^3 A) 2.2x10^{-2} N **B**) 8x10^{-2} N) C) 2x10^{-2} N D) 5x10^{-2} N

Answer B

35. A substance whose density is $\varrho s = 0.\ 2x103$ kg/m ^{3} floats in fresh water ($\varrho f = 1000kg/m3$)

What fraction of its volume is submerged A) 0.5 **B)** 0.2 C) 0.1 D) 0.9

Answer B

36. A Horizontal pipe of cross section area of 4cm ^{2} has constriction of cross section 0.01cm^2 . water flows with a speed of 6m/s in the large pipe . What is the speed of water in the constriction

A) 3400m/s B) 5000m/s C) 2500m/s **D**) 2400m/s

Answer D

37. A liquid flows through a tube having a uniform cross-section of 0.04m^2 at an average velocity of 20m/s . What is the *rate of flow* *A*) $0.\ 8m3/s$ *B*) $8m3/s$ *C*) $0.\ 2m3/s$ *D*) $0.\ 6m/s$

Answer A

38. *water flows through the Horizontal* pipe with a speed of 15m/s where the pressure is 1.5x10^5 pa and the cross sectional area is 4cm^2 .what is the pressure at appoint where the cross sectional area of the pipe is 12cm ^{2} A) 1.01x10^{5}pa B) 2x10^{5}pa **C**)2.5 x10^{5}pa D) 5x10^{5}pa

Answer C

39. Which of the following is not true about fluids

A) Liquids and gases differ markedly in their compreseblities

B) The density of gas depends on the pressure and volume at which it is measured

C) Water is more dense in temperature of 0 ℃ *to* 4℃ D) None of the above

Answer D

40. Atmospheric pressure depends upon

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A) Temperature B) Altitude C) Density of mercury **D**) A and B **Answer D**

41. *With increase of temperature the forbidden energy gap of semiconductor is*

A) Increase ***B)*** *Decrease C. Remains constant D) Unknown*

Answer B

42. *In a p type semiconductor current conduction is by ----------*

A) Atoms ***B*** *) Holes C) Electrons D) Protons*

Answer B

43. *In reverse biasing*

A) Large amount of current flows
B) No current flows
C) Potential barrier across junction increase
D) Resistance decrease
E) B and C

Answer E

44. *Main function of transistor is ----------*

A) Rectify B) Simplify **C***) Amplify D) Converting*

Answer C

45. *To obtain P . type silicon semiconductor we need to dope pure silicon with*

A) Aluminum B) Phosphorous C) Oxygen D) Germanium

Answer A

46. *On applying reverse biased to junction diode it ----------*

A) Lowers the potential barrier ***B****.) Raise the potential barrier*
C) increase majority carrier D) increase minority carrier

Answer B

47. *To obtain electrons as majority charge carrier in semi conductor the impurity mixed A)* Monovalent ***B) divalent C) trivalent D) pentavalent*** *Answer D*

48. ***On heating resistance*** *of semi conductor*

A) Decrease B) increase C) remains constant D) increase and decrease

Answer A

49. *P n junction diode used as A) Amplifier B) Oscillator* ***C****) Rectifier D).Modulator*

50. *When A P N junction does not conduct it is*

A) Reverse biased B) Forward biased C) Breaker voltage D) Avalanche effect

Answer A

51. *A semi conductor material is made in to N type by*

A) Adding an accepter impurity B) Adding a donor impurity C) injecting

Answer B.

52. *Which of the following does not result from adding an accepter impurity*

A) The material becomes p type B) Current flows mainly in the form of holes
C) most of the carriers have positive electric charge ***D****) the substance has an electron surplus*

Answer D.

53. *In P type materials electrons are*

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A) Majority carriers B) Minority carriers C) Positively charged D) Entirely absent

Answer B minority carriers

53. *In which materials its electrical conductivity is a function of temperature alone*

A) Insulators B) Conductors C) Semiconductors D) All

Answer C semi conductors

54. *The part of transistor which is highly doped is ----------*

A) Base B) Collector C) Emitter D) Diode

Answer C Emitter is highly doped

55. *Which type of diode is connected forwarding biased*

A) Photodiode B) Light emitting diode C) Zener diode D) Golden Diode

Answer A photodiode performs only forwarding biased

56. *Angle of incidence is always equal to angle of reflection , this law is valid for the phenomena of the wave of* ----------

A) Diffraction B) Refraction C) Reflection D) All

Answer C reflection

57. *The phenomena of bending of light wave from one medium to another medium is* ----------

A) Interfacing B) Reflection C) Refraction D) Diffraction

Answer C Refraction

58. *Which type of wave needs a material medium*

A) Light wave B) Sound wave C) X ray wave D) All

Answer B sound wave

59. *The image which can not be obtained by a screen is called*

A) Real B) Inverted C) Virtual D) Focus

Answer C virtual image only obtained by plane mirror

60. *The change of the right side of the image becomes the left side of the image is*

A) Principal focus B) Lateral inversion C) Focal point D) Principal axis

Answer B Lateral inverssion

61. *When an object is placed between the pole and the focus of a concave mirror the image formed is* ..

A) Diminished in size B) Small in size C) Larger in size D) In front of the mirror

Answer C larger in size

62. *The angle of incidence in the denser medium for which the angle of refraction is 90 is called*

A) Refracted angle B) Reflected angle C) Critical angle D) Incident angle

Answer C critical angle

63. *Which of the following is true about light*

A) When light passé from a medium of large refractive index in to an other of smaller refractive index the refracted ray is bent away from the normal

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B) *Total internal reflection occurs when the angle of incidence is smaller than the critical angle*

C) *Light travels faster in water than in air*

D) *As light travels from denser medium to less denser medium the frequency of light wave decrease*

Answer A

64. *Which of the following statement is true about total internal reflection*

A) *Light travels from air to water*

B) *Light travels from denser to lighter medium*

C) *Light travels from lighter to denser medium*

D) *All are correct*

Answer B

65. *Which of the following is does not affected by refractive index of a medium*

A) *Frequency* B) *Wavelength* C) *Speed* D) *All*

Answer A

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Unit -7: Review and Summary of Thermodynamics

7.1 Short notes on thermodynamics

- If two systems are each in thermal equilibrium with a third system, then they must be in thermal equilibrium with each other; that is, thermal equilibrium is transitive.
- If Temp(A) = Temp(B) and Temp(B) = Temp(C) then Temp(A) =Temp(C).
- Temperature defines the direction of heat flow between two bodies. If two bodies are in thermal equilibrium, there is no net heat flow between the two bodies and they are both at the same temperature.
- **Avogadro's number** $N_A = 6.02x10^{23}$ is the number of molecules in a mole. The **molar mass** of a substance is the mass of 1 mole of the substance.
- The phase diagram of a substance indicates the phase and phase change of that substance relative to pressure and temperature.
- The **molar heat capacity** is the amount of heat required to change the temperature of 1 mole of material by 1 Kelvin.
- The molar specific heat of an ideal gas at constant volume c_v and at constant pressure c_p are related by: $c_p - c_v = R$.
- Broad restatement of the conservation of energy and is found to hold for all processes.

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- The **first law of thermodynamics** states that when heat Q is added to a system while work W is done by the system, the internal energy U changes by an amount

$$\Delta U = Q - W$$

- Four simple thermodynamic processes are:

1. **Adiabatic process:** No heat transfer in or out of a system; $Q = 0$

For an adiabatic process on ideal gases these equations hold true: $PV^{\gamma} = constant$ $T^{\gamma}P^{1-\gamma} = constant$ and $TV^{\gamma-1} = constant.$

2. **Isochoric process:** Constant volume process W=0 and the first law of thermodynamics takes the form $\Delta U = Q$
3. **Isobaric process:** Constant pressure process. No variable in the first law has zero value. The first law of thermodynamics takes the form $\Delta U = Q - W$
4. **Isothermal process:** Constant temperature process. If the system is an ideal gas, then $\Delta U = 0$ and PV=constant. The first law of thermodynamics become $W = Q$

Equation of states and kinetic theory of gasses

- The pressure, volume, and temperature of a given quantity of a substance are called state variables; they are related by an equation of state. The equation of state for an ideal gas is the **ideal-gas equation:** $PV = nR$
- The average translational kinetic energy of n moles of an ideal gas is directly proportional to the absolute temperature of the gas. The average translational kinetic energy of a molecule of a gas is a function of the absolute temperature only. $K_{av} = \frac{3}{2}kT$
- With all the assumptions of an ideal gas the kinetic theory states that $P = \frac{1}{3}\rho v_{rms}^2$.
- The internal energy of an ideal gas depends only on its temperature, not on its pressure or volume.

Directions of Thermodynamic Processes (Second law of thermodynamics)

- Heat flows spontaneously from a hotter object to a cooler object, never the reverse.
- A **reversible process, equilibrium process,** is a process whose direction can be reversed by an infinitesimal change in the conditions of the process.
- Entropy is the measure of disorder in a system.
- The second law of thermodynamics can be stated in several equivalent ways:

I. heat flows spontaneously from a hot object to a cold one, but not the reverse.

II. there can be no 100% efficient heat engine-that is, one that can change a given amount of heat completely into work.

III. Natural processes tend to move toward a state of greater disorder or greater entropy.

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- The most general statement of the second law of thermodynamics can be restated as: the **total entropy**, S, of any system plus that of its environment increases as a result of any natural process it **never decreases.**

Heat engines and maximum theoretical efficiency

- A heat engine is a device that converts heat partly to mechanical work.
- The efficiency of a heat engine is given by $\eta = 1 - \frac{Q_c}{Q_h}$
- The **Carnot cycle (maximum efficiency)** operates between two heat reservoirs at temperatures T_H and T_c and uses only reversible processes. Its thermal efficiency is

$$e_{max} = 1 - \frac{T_c}{T_h}$$

- All Carnot engines operating between the same two temperatures have the same efficiency.

7.2 Topics Related Questions on Unit 8

I. Choose the best answer from the given alternatives.

1. A given weight of gas has a temperature of 27^0c and volume V. Keeping the pressure constant, the volume is increased to 3V by varying the temperature. What is the final temperature of the gas?
   A) 81^0c B) 546^0c C) 627^0c D) 900^0c

   Solution: $T_1 = 27^0 C, V_1 = V, V_2 = 3V, P = cons\tan t$ T_2=?

   P=constant. From Charles' law → $\frac{V}{T} = constant$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (remember that the temperature must be in Kelvin) T_1=273+27=300 K; T_2=?

   ⇨ $\frac{V}{300} = \frac{3V}{T_2}$ (eliminating V)

   ⇨ $T_2 = 900K$

   ⇨ 900 K = T_c +273. Therefore, T_c = 627 ^{0}c

2. Suppose two molecules of different mass are kept at the same temperature. Which one of the following statements is **NOT** true? A) Both remains at rest. (B) Both move with the same speed.
   C) The lighter molecule moves faster. D) The heavier molecule moves faster.
   Brief explanation: the speed of gas molecules is inversely proportional to the square root of their molecular and molar mass.

- According to the kinetic theory of gasses, the molecules of a gas are always in random motion. And their speed depends on temperature and mass according to the equations $v = \sqrt{\frac{3RT}{M}}$ or $v = \sqrt[3]{\frac{}{m}}$. We can see that the speed of molecules is inversely proportional to m and M. Hence, choice C is correct.

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3. An ideal gas is at a temperature of 300 K. If we wish to double the r-m-s speed of the molecules of the gas to what value must we raise the temperature?

A) 450 K B) 600 K C) 800 K D) 1200 K

Solution: Let the r-m-s speed of the molecules at 300 K be $v_1 = \frac{3(300K)}{M}$, *but what we want is* $v_2 = 2v_1$ $\sqrt{\frac{3RT}{M}} = 2\sqrt{\frac{3R(300K)}{M}}$, *squaring both sides,* $T_2 = 4(300K) = 1200K$ (D)

4. Gas at pressure P is contained in a vessel. If the masses of all the molecules are doubled and their speeds halved then what will be the resulting pressure?

A) 2 P B) $\frac{P}{3}$ C) $\frac{P}{2}$ D) 3P

Solution: Remember the basic kinetic theory equation

$P = \frac{1}{3}\rho v^2$ $PV = \frac{2}{3}N\left(\frac{1}{2}mv^2\right)$, When $m_2 = 2m$ *and* $v_2 = \frac{v}{2}$.

$P_2 = \frac{2}{3}\frac{N}{V}\left(\frac{1}{2}m_2 v_2^2\right) = \frac{2}{3}\frac{N}{V}\left(\frac{1}{2}2m\left(\frac{v}{2}\right)^2\right)$

$P_2 = \frac{2}{3}\frac{N}{V}\left(\frac{1}{4}mv^2\right) = \frac{1}{2}\left(\frac{2}{3}\frac{N}{V}\left(\frac{1}{2}mv^2\right)\right) = \frac{1}{2}P$ *(Answer C)*

5. which of the following statements follows from the kinetic theory of gasses?

A) The pressure of the gas is proportional to the average square of molecular speed of particles.
B) The molecules undergo inelastic collisions with each other and with the walls of their container.
C) The forces between molecules of gas are strong at all times.
D) Newton laws of motion is the consequence of the kinetic theory of gasses.

Brief explanation: conceptualize the kinetic theory of gasses. Go back and refer to the assumptions of the kinetic theory and related equations. **Choice A is correct.**

6. The temperature of a gas is due to

A) The kinetic energy of the molecules B) The potential energy of the molecules
C) The attractive force between the molecules D) The repulsive force between the molecules. **Brief explanation:** recap the basic factors that affect the temperature of ideal gases. According to the kinetic theory of gases, temperature is the measure of the average translational kinetic energy of gases. And there is no interaction between the gas molecules except during collision. Choice A is correct.

7. The first law of thermodynamics takes the form $dU = dW$. This equation is valid if the process is

A) Isobaric B) isochoric C) isothermal D) adiabatic

Brief explanation: In adiabatic thermodynamic process $Q = 0$ and $du = dQ + W$ (W is work done on the system). First law of thermodynamics can be stated as $dU = dQ + dW$. Here dW is the work done on the system. But for **adiabatic process**, $dQ = 0$ and $dU = dW$. **D is correct**

8. An ideal gas undergoes an isothermal process with pressure of $2x10^5$ Pa and a volume of $3\ m^3$. Which one of the following might be the pressure and volume of the final state?

A) $4x10^5$ Pa and $4\ m^3$ B) $4x10^5$ Pa and $3\ m^3$ C) $5x10^5$ Pa and $3\ m^3$ (D) 10^5 Pa and $10\ m^3$

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Solution: Given $P_1 = 2x10^5\,Pa \quad V_1 = 6m^3$ **Required** $P_2 = ?\ , V_2 = ?$

An isothermal process is a constant temperature process. If the process is isothermal process and your system is an ideal gas then: $= constant, P\,V = P_1\ _1$. **Choice B is correct**.

9. What does a curve drawn between two points on PV diagram represent?

A) The state of the system. B) A thermodynamic process.

C) Work done in an acyclic process. D) Work done on or by the system.

Brief explanation:

- The state of a system is a single point on PV diagram
- Work done by or on the system in any process, is the area under PV diagram

A thermodynamic process is a process that takes a system from initial state to a final state. It is depicted on a PV diagram. **Choice B is correct.**

10. Which one of the following statements is NOT correct?

A) The entropy of the universe increases in all-natural processes.

B) No heat engine operating in a cycle can absorb energy from a reservoir and use it entirely to do work.

C) When a system undergoes a change in state, the change in its internal energy is the difference between the energy transferred to it by heat and the work done on it.

D) The entropy of an isolated system reaches its maximum value when the system is in equilibrium state.

Brief explanation: Choices A and B are undoubtedly true. Since both of them are statements of the second law of thermodynamics. Choice D is also TRUE. When the system is in equilibrium state the processes are all REVERSIBLE, which means that $\Delta S = 0$. The entropy cannot increase any more. It is at its maximum value. BUT choice C is NOT correct. When work is done on a system during its change from one state to another, the change in its internal energy is the **sum** between the energy transferred to it by heat and the work done on it ($\Delta U = Q + W_{on}$) not the **difference.**

11. The change in entropy is zero for:

A) Reversible isobaric process. B) Reversible adiabatic process.

C) Reversible isothermal process. D) Reversible process during which no work is done

Brief explanation: The ΔS in reversible process depends on the energy transferred as heat according to the equation $\Delta S = \frac{Q_r}{T}$ and for adiabatic process $Q_r = 0$. $Therfore, \Delta S = 0$.(**choice B is correct**)

12. A heat engine is being designed to have a Carnot efficiency of 65% when operating between two heat reservoirs. If the temperature of the cold reservoir is 20℃What must be the temperature of the hot reservoir? A) 57℃ B) 310℃ C) 564℃ D) 807℃

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Solution: The Carnot efficiency is the maximum theoretical efficiency ($e_{max} = 1 - \frac{T_c}{T_h}$). T_c and T_h must be in absolute scale. $e_{max} = 65\%$, $T_c = 20°C$ T_h in Celsius scale=? The absolute temperature of the cold reservoir is $T_c = 20°C + 273 = 293K$. If the Carnot efficiency is to be $e = 0.65$. it is necessary that $1 - \frac{T_c}{T_h} = 0.65$ or $\frac{T_c}{T_h} = 0.35$ and $T_h = \frac{T_c}{0.35}$. Therefore, $T_h = 837K$ or $T_h = 837 - 273$

$T_h = 564°C$. (C *is correct*)

13. In a reversible thermodynamic process, the system
    A) is always close to equilibrium state. B) might never be close to any equilibrium state.
    C) is close to equilibrium state only at the beginning and end.
    D) is close to equilibrium states, throughout, except at the beginning and end.
    Brief explanation: reversible thermodynamic processes are in equilibrium within and with the external environment. All reversible processes are always close to equilibrium states.
    (Choice A is correct)
14. An ordinary refrigerator is turned on and its door is left open in a thermally insulated kitchen. What is the temperature of the room?
    A) increases according to the first law of thermodynamics.
    B) decreases according to the first law of thermodynamics.
    C) remains constant according to the first law of thermodynamics.
    D) remains constant according to the second law of thermodynamics.
    Brief explanation: The refrigerator is a heat engine which (with an input of work) takes heat from the low-temperature reservoir (inside the refrigerator) and exhausts heat to the high-temperature reservoir (the room). As shown by the first law of thermodynamics more heat will be exhausted into the room than removed from the inside of the refrigerator.
    Q_h (*exhausted heat to the high temperature reservoir*) $= Q_c + W_{in}$. Thus, leaving the refrigerator door open will actually warm the kitchen. **Choice A is correct**
15. If the internal energy of a system decreases, then what can be concluded about the heat and work done?
    A) Heat is added to the system and work is done by the system.
    B) Heat is removed from the system and work is done on the system.
    C) Heat is added to the system and work is done on the system.
    D) Heat is removed from the system and work is done by the system.

    Brief explanations: From the first law of thermodynamics $\Delta U = Q - W$ where Q is the heat added or removed and W is the work done by/on the system.

❖ When applying the first law of thermodynamics, it is important to determine the proper signs for Q, W, and ΔU.

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Q positive	System *gains* heat
Q negative	System *loses* heat
W positive	Work done *by* system
W negative	Work done *on* system

- If you apply the sign conventions given here, it is straightforward to verify that adding heat to a system, and/or doing work on it, increases the internal energy.
- On the other hand, if the system does work, and/or heat is removed, its internal energy decreases. Therefore, **choice D is correct**.

16. If a thermodynamic system undergoes a process in which its internal energy increases by 400J while doing 200 J of work on its surrounding, then what is the energy absorbed in or extracted from it in the form of heat?

A) -600 J B) 600 J C) 200 J D) -200 J

Solution: from the question $\Delta U = +400J,\ W = +200J$. Therefore,

$+400\,J = Q - (200\,J) \Rightarrow \underline{\underline{Q = +600\,J}}$ (Heat is added).

17. A heat engine operating between 100^0C and 700^0C has efficiency equal to 40 % of the maximum theoretical efficiency. How much energy does this engine extract from the hot reservoir in order to do 5000 J of mechanical work?

A) 810.4 J B) 81.0 J C) 20275.75 J D) 20.3 J

Solution $e = \dfrac{W}{Q_H}$ And $e_{\max} = 1 - \dfrac{T_c}{T_H}$ where T_c *and* T_H are in Kelvin.

$e_{\max} = 1 - \dfrac{373}{973} \Rightarrow e_{\max} = 0.6166$ since the efficiency is 40% of the maximum theoretical efficiency, $e = \dfrac{W}{Q_H} = \left(\dfrac{40}{100}\right)(0.6166) = 0.2466 \quad \dfrac{5000\,J}{Q_H} = 0.2466 \Rightarrow \underline{\underline{Q_H = 20275.75}}$.

18. Which of the following must be true about an ideal gas that undergoes an isothermal expansion?

A) No heat enters the gas. B) The pressure of the gas decreases.

C) The internal energy of the gas does not change. D) The gas does negative work.

Brief explanation: an isothermal process is a constant temperature process and the internal energy of an ideal gas is a function of temperature only. Choice C is correct.

19. If the temperature of an ideal gas is increased from 200 K to 600 K, what happens to the r-m-s speed of the molecules?

A) It increases by a factor of 3. B) It remains the same.

C) It is one-third of the original speed. D) It is $\sqrt{3}$ times the original speed.

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Solution: the r-m-s speed of gas molecules is directly proportional to the square root of the absolute temperature. $v_{rms} = \sqrt{\frac{3RT}{M}}$. Hence, $\frac{v_1}{v_2} = \frac{\sqrt{T_1}}{\sqrt{T_2}}$. $\frac{v_1}{v_2} = \frac{200}{\sqrt{600}}$. $\frac{v_1}{v_2} = \frac{1}{\sqrt{3}}$. Choice D is correct.

20. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process until its volume is again reduced to half. Then

A) Compressing the gas isothermally or adiabatically will require the same amount of work.

B) Which of the cases (whether compression through isothermal or through adiabatic process) requires more work will depend upon the atomicity of the gas.

C) Compressing the gas isothermally will require more work to be done.

D) Compressing the gas through an adiabatic process will require more work to be done.

Brief explanation: starting at the same point on a P-V graph, the curves for an adiabatic and isothermal processes will diverge and the adiabatic curve will have a steeper slope. For the same reduction in volume adiabatic curve will be above the isothermal curve, and will enclose greater area under it for the same reduction in pressure, and since the area gives the work required, isothermal work is smaller than adiabatic for the same reduction in volume. Choice D is correct

21. Two moles of an ideal gas at a temperature of 308 K is confined in a volume of $5x10^{-3}m^3$. The pressure of the gas is_____(universal gas constant R=8.314J/mol.K)

A) $1x10^6$ Pa B) $5.12x10^6$ Pa C) $1.02x10^6$Pa D) $1.23x10^6$ Pa

Hint: use the equation of states, $PV = nRT$ and $P = \frac{nRT}{V}$. The answer is choice C.

22. A glass contains 12 mol 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 g and O is 16 g)

A) $72.24x10^{23}$ molecules, 0.216kg, $29.9x10^{-26}$kg

B) $90.32x10^{23}$ molecules,0.192 kg,$18x10^{-26}$kg

C) $102x10^{23}$ molecules,0.024 kg, $6.02x10^{-26}$ kg

D) $96.32x10^{23}$ molecules,0.036 kg, $0.009x10^{-26}$ kg

Brief explanation and solution.

- The number of particles (or molecules) in a mole of a substance is N_A (Avogadro's number = N_A= $6.02x10^{23}$ particles/mole.) $N = nN_A$. Here N is the number of particles and n is the number of moles.
- Molar mass (M) is the mass of one mole of a substance. $M = \frac{m_s}{n}$. m_s is the mass of the given sample.
- $m_s = Nm$. M is the mass of each molecule of the substance. So rearrange and solve the

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equations.

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$N = nN_A$ for the number of molecules. $m_s = nM$ for the mass of the water and $m = \frac{m_s}{N}$ for the mass of each water molecule. **The correct answer is A**

23. In a thermodynamic process 1.5x 10^5 J of heat is added to an ideal gas to keep the pressure constant at 2x10^5 Pa while the volume increases from 6.3 m^3 to 7.1 cm^3. The change in the internal energy of the gas is _____

A) 1x10^4 J B) 3.1x10^4 J C) 14.1x10^4 J D) -1x10^4 J

Brief explanation and solution: From the first law of thermodynamics $\Delta U = Q - W$. Q $= +1.5x10^5$ J and $\Delta V = (7.1 - 6.3)$ ^{3} and $P = 2x10^5 Pa$. Then, $\Delta U = Q - P\Delta V$. The answer is choice D.

24. A sample mixture of gas contains 72% of hydrogen and 28 % of Helium. What is the partial pressure of Helium at an atmospheric pressure of 76 cm of mercury (Hg)?

A) 54.72 cm of Hg B) 21.28 cm of Hg C) 33.44 cm of Hg D) 76 cm of Hg

Brief explanation and solution: ***Partial pressure*** is the pressure that each gas would exert if it alone occupied the volume containing the mixture. Total pressure of mixture of gases = sum of pressures that each would exert if it were alone. The partial pressure of a gas in a container depends on the amount of that gas in the container.

For two mixture of gases in a container for instance, $\frac{P_2}{P_{total}} = \frac{n_2 RT/V}{(n_1 + n_2)(RT/V)} = \frac{n_2}{n_1 + n_2}$. Therefore, $\frac{P_{He}}{P_{total}} = \frac{(28\%)_{total}}{n_{total}}$. Thus, $\frac{P_{He}}{P_{total}} = (28\%)\ P_{He} = \left(\frac{28}{100}\right)76\ cm\ of\ Hg$. The answer is choice B.

25. As the pressure in an ideal gas is increased isothermally the average molecular speed:

A) Increases B) stays the same

C) increases at high temperature, decreases at low D). decreases at high temperature, increases at low

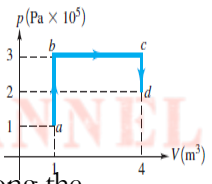
Brief explanation: The average **molecular** speed of an ideal gas depends only on temperature **only**. Therefore, if the process occurs at constant temperature (isothermally) the average molecular speed stays the same. The answer is B.

26. Gas x has a molar mass of 72 gm/mol and Gas y has a molar mass of 2 gm/mol. How much faster or slower does Gas y diffuse than gas x at the same temperature?

A) 2 times B) 4 times C) 6 times D) 8 times

Brief explanation: According to Graham's law of diffusion, the rate of diffusion is inversely proportional to the square root of both the mass and density of the gas molecules.

$\frac{r_x}{r_y} = \sqrt{\frac{M_y}{M_x}} = \sqrt{\frac{2}{72}} = \frac{1}{6}$. The answer is C.



27. For the process shown in the *p* -*V* diagram in Figure, the total work in going from *a* to *d* along the path shown is _____

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A) $15x10^{5}\,J$. B) $9x10^{5}\,J$. C) $6x10^{5}\,J$ D) $1x10^{5}\,J$.

Brief explanation: work is not a state variable and can be easily calculated by finding the area under P-V curve. The answer is B.

28. For a temperature increase of ΔT_1, a certain amount of an ideal gas requires 30 J when heated at constant volume and 50 J when heated at constant pressure. How much work is done by the gas in the second situation? A) 20J B) 30J C) 50J D) 80J

Brief explanation: For any process on ideal gas the change in internal energy is $\Delta U = nc_v \Delta T$. Moreover, ΔU is the same for the two processes (since the change in temperature is the same in both processes). Therefore, for the isochoric process $Q_v = nc_v \Delta T = \Delta U = 30J, nc_v \Delta T = 30J$ and for the isobaric process

$Q_p = \Delta U + W$ and since $\Delta U_p = \Delta U_v$ we can say that $50 = 30 + W$. The answer is A

29. The energy absorbed as heat by an ideal gas for an isothermal process equal:

A) The work done by the gas B) the work done on the gas

C) The change in the internal energy of the gas D)The negative of the change in internal energy of the gas

Brief explanation: For an isothermal process on an ideal gas, $\Delta u = 0$. The mathematical form of the first law of thermodynamics is $\Delta u = Q - W$. Thus, when $\Delta U = 0$, the first law of thermodynamics takes the Form: $W = Q$. The answer is A.

30. A steam engine absorbs 600 J of heat at 500 K and the exhaust temperature is 300 K. If the actual efficiency is only half of the ideal efficiency, how much work is done during each cycle?

A) 40 J B) 80 J C) 120 J D) 160J

Hint: ($actual\ efficiency = \frac{W}{Q_h}$ and $ideal\ efficiency = 1 - \frac{T_c}{T_h}$). In addition, $\eta_{actual} = \frac{1}{2}\eta_{ideal}$. The answer is C.

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Unit 8: Review and Summary of Oscillations and Waves

8.1 Short notes on Oscillations and Waves

- **Simple harmonic motion** is an oscillatory motion where the acceleration is proportional to the displacement but opposite in sign.
- The defining equation of simple harmonic motion is $a = -\omega^2 x$
- For an oscillator performing simple harmonic motion:
  1. The period does not depend on the amplitude
  2. $x(t) = A\cos(\omega t + \phi_0)$ …. the position, $v(t) = -\omega \sin\left(\omega t + \phi_0\right)$ …. the velocity and $a(t) = -\omega^2 A\cos(\omega t + \phi_0)$ …. the acceleration.
  3. The velocity of a simple harmonic oscillator at any point is given by $v = \pm\omega\sqrt{x_0^2 - x^2}$
- The **total energy** of a simple harmonic oscillator is **proportional** to **the square of the amplitude.**
- When systems oscillate due to additional external force applied that has its own particular frequency(f)The oscillation is called forced oscillation.
- When the motion of the oscillator is reduced by an external dissipative force (F_d), the amplitude decreases in time and the oscillation is called damped oscillation.
- Resonance occurs when an oscillator is driven at its natural frequency.
- Damping forces are opposite in direction to velocity and dissipate energy, causing an exponential decay in the amplitude of free oscillation.

Wave Motion

- Mechanical waves are disturbances that propagate through a material medium.
- The speed of propagation of a mechanical wave depends on the mechanical properties of the medium.
- The **speed** of a transverse wave in a rope under tension is **proportional** to the square root of the tension, divided by the mass per unit length.
- The function of a wave traveling to the right is $y(x, t) = A\sin(kx - \omega t)$.

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- The principle of superposition states that the net displacement of the medium at any point in space or time, is simply the sum of the individual wave's displacement.
- If two sinusoidal waves of the same amplitude and wavelength travel in *opposite* directions along a stretched string, their interference with each other produces a **standing wave**.
- For standing wave on a stretched string, the wavelength of the n^{th} mode of oscillation is $\lambda_n = \frac{2L}{n}$.
- The harmonic frequencies are $f_n = n\frac{v}{2L}$. **Nodes** are points where the two waves interfere **destructively**. **Antinodes** are points where the two waves interfere constructively.
- For a pipe closed at one end the fundamental mode of oscillation occurs when $\lambda_n = \frac{4}{n}$. Only odd harmonics can occur. The intensity of a sound is directly proportional to the square of the amplitude and frequency.
- *Beats* arise when two waves having slightly different frequencies, f_1 and f_2, are detected together.

Sound, loudness and the human ear.

- The sound level or intensity level of a sound is $\beta = 10\left(\frac{I}{I_0}\right)$ or $\Delta\beta = 20\left(\frac{r_2}{r_1}\right)$.
- The ***Doppler effect*** is a change in the observed frequency of a wave when the source or the detector moves relative to the transmitting medium.
- **Single equation that covers all cases** of both source and observer in motion is

$$f' = \frac{(v \pm v_o)}{(v \mp v_s)} f$$

9.2 Topics Related Questions on Unit 9

I. Choose the best answer from the given alternatives.

1. A point source broadcasts sound into a uniform medium. If the distance from the source is tripled, how does the intensity change?

A) it remains unchanged B) it becomes three times larger
C) it becomes one-third as large. D) it becomes one-ninth as large.

Solution: $r_2 = 3r_1$, $I_2 = ?$

$$\frac{I_1}{I_2} = \left(\frac{r_1}{r_2}\right)^2 \Rightarrow \frac{I_1}{I_2} = \left(\frac{3r_1}{r_1}\right)^2 \Rightarrow \frac{I_1}{I_2} = 9 \Rightarrow I_2 = \frac{I_1}{9}$$

. The answer is D.

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2. The loudness of sound changes from L_1=30 dB to L_2 = 60 dB. What is the ratio of intensities $\frac{I_2}{I_1}$ in the two cases? A) 2 B) 4 C) 600 D) 1000.

$$\beta_2 - \beta_1 = 10\log^{I_2} - 10\log^{I_1} \Rightarrow L_2 - L_1 = 10\log^{\left(\frac{I_2}{I_1}\right)}$$

$$\Rightarrow 30 = 10\log^{\left(\frac{I_2}{I_1}\right)} \Rightarrow \left(\frac{I_2}{I_1}\right) = 1000$$

Brief explanation: The answer is D

3. A pipe, 68 cm long, is open at one end and closed at the other. When air is blown across the open-end sound is produced at 110 Hz. What is the velocity of sound along the pipe?
A) 598.4 m/s B) 334.6 m/s C) 299.2 m/s D) 149.6 m/s

Solution: $l = 68\,cm, f_1 = 110Hz$ .The fundamental frequency produced by a closed pipe is given by:

$$f_1 = \frac{v}{41} \Rightarrow v = 4 f_1 l \Rightarrow v = 4(110Hz)\left(\frac{68}{100}m\right) \Rightarrow v = 299.2\,m/s$$

. The answer is C.

4. If the amplitude of a sound wave is doubled, the intensity
A) remains the same B) increases by a factor of 2
C) increases by a factor of 4 D) increases by a factor of 16
Hint: the intensity of a sound is directly proportional to the square of the amplitude. The answer is C

5. The sound level at a distance of 4 m from a source is 120 dB. At what distance is the sound level 100 dB?
A) 0.4 m B) 4.80 m C) 40 m D) 48 m

Solution: $r_1 = 4m, \beta_1 = 120dB, \beta_2 = 100dB \quad r_2 = ?$
Remember the sound level formula

$$\beta_1 - \beta_2 = 10\log^{\left(\frac{I_1}{I_0}\right)} - 10\log^{\left(\frac{I_2}{I_0}\right)}$$

$$\Rightarrow \beta_1 - \beta_2 = 10\log^{\left(\frac{I_1}{I_2}\right)} = 10\log^{\left(\frac{r_2}{r_1}\right)^2}$$

$$\Rightarrow 120dB - 100dB = 10\log^{\left(\frac{r_2}{r_1}\right)^2} \Rightarrow 20 = 10\log^{\left(\frac{r_2}{r_1}\right)^2}$$

$$\Rightarrow 100 = \left(\frac{r_2}{4}\right)^2 \Rightarrow \left(\frac{r_2}{4}\right) = 10 \Rightarrow r_2 = 40m$$

The answer is choice C.

6. A transverse sinusoidal wave is traveling on a string. Which statement is correct about a point on the string?
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

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D) the point moves in uniform circular motion with a different angular speed than the wave.

Brief explanation: in propagation of mechanical waves, the wave does not move along with the material medium. However, the particles execute simple harmonic motion when the wave moves in a certain direction. Choice C is correct

7. What makes the oscillatory motion a simple harmonic motion?

A) The acceleration of the motion is directly proportional in magnitude but opposite in direction to the displacement.

B) The acceleration of the motion is directly proportional to the velocity.

C) The velocity of the motion is directly proportional to the displacement.

D) The velocity of the motion is inversely proportional to the displacement.

Brief explanation

An object moves with simple harmonic motion whenever its acceleration is proportional to its position and is oppositely directed to the displacement from equilibrium. **Choice A is correct** .

8. The two-end fixed string of length 0.5 m has a mass per unit length 2g/m. If the tension in the string is 80 N, what is the second harmonic frequency?

A) $100\sqrt{2}\ Hz$ B) 200 Hz C) 400 Hz D) 600 Hz

Brief explanation and solution: The second harmonic of a vibrating string is given by

$f_2 = 2f_1 = 2\left(\frac{v}{2l}\right) \Rightarrow f_2 = \frac{v}{l}, \text{ and}$ the speed of traveling wave on a string is given by

$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{80N}{0.002kg/m}} = 200m/s$. Therefore, $f_2 = \frac{200\,m/s}{0.5m} \Rightarrow \underline{\underline{f_2 = 400\,Hz}}$.

Choice C is correct.

9. An organ pipe open at one end, but closed at the other, is vibrating in its fundamental mode, producing sound of frequency 1000 Hz. If you now open the closed end, the new fundamental frequency will be

A) 2000 Hz. B) 1000 Hz. C) 500 Hz. D) 250 Hz.

Solution:

$fundamental\ of\ closed\ pipe = 1000Hz = f_{closed} = \frac{v}{4l}\ and$

$fundamental\ of\ open = f_{open} = \frac{v}{2l}$

$f_{closed} = \frac{f_{open}}{2} \Rightarrow f_{open} = 2000\,Hz$. Choice A is correct.

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10. To produce beats, it is necessary to use two waves:
A) traveling in opposite directions B) of slightly different frequencies
C) of equal wavelengths D) of equal amplitudes
Brief explanation: beat is produced by the interference of two identical waves of slightly different frequencies. Choice B is correct.

11. An organ pipe open at one end, but closed at the other, is vibrating in its fundamental mode, producing sound of frequency 1000 Hz. If you now open the closed end, the new fundamental frequency will be
A) 2000 Hz. B) 1000 Hz. C) 500 Hz. D) 250 Hz.

Solution: $fundamental\ of\ closed\ pipe = 1000Hz = f_{closed} = \frac{v}{4l}$ and **Required:** $fundamental\ of\ open = f_{open} = \frac{v}{2l}$. Since $f_{closed} = \frac{f_{open}}{2} \Rightarrow f_{open} = 2000\,Hz$. Choice A is correct.

12. Which of the following frequencies are higher harmonics of a string with fundamental frequency of 150 Hz? A) 200 Hz B) 300 Hz C) 400 Hz D) 500 Hz **Solution:** $f_1 = 150Hz$ is the fundamental frequency. Harmonics of the fundamental=?

The harmonics are $f_n = nf_1$. Therefore, the harmonics are: 150 Hz, 300 Hz, 450 Hz, 600 Hz. Choice B is correct.

13. If a 1 kHz sound source moves at a speed of 50 m/s toward a listener who moves at a speed of 30 m/s in a direction away from the source, what is the apparent frequency heard by the listener? (The speed of sound is 343 m/s.) A) 796 Hz B) 949 Hz C) 1000 Hz D) 1070 Hz
Solution

$$f_{source} = 1kHz, v_{source} = 50m/s, v_{observer} = 30m/s, f' = f\left(\frac{v_{snd} \mp v_{observer}}{v_{snd} \pm v_{source}}\right)$$

Since the source is moving towards a listener and the observer is moving away from the source

$$f' = f\left(\frac{v_{snd} - v_{observer}}{v_{snd} - v_{source}}\right) \Rightarrow f' = 1000Hz\left(\frac{343-30}{343-50}\right)$$

$$\Rightarrow f' = \left(\frac{313}{293}\right)1000Hz = 1070Hz$$

Choice D is the answer.

14. What is the speed of a transverse wave in a rope of length 2.00 m and mass 60.0 g under a tension of 500 N?
A) 129 m/s B) 548 m/s C) 244 m/s D) 674 m/s

Solution: $l = 2m, m = 60gm, T = 500N$ v =?

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$\mu = \frac{m}{l} = \frac{0.06kg}{2m} = 0.03kg/m$. And $v = \sqrt{\frac{T}{\mu}} \Rightarrow v = \sqrt{\frac{500\,N}{0.03}} = 129\,N$. Choice A is correct.

15. A 1 kg mass is attached to a spring of stiffness constant 100 N/m. What is the maximum displacement of the mass from its equilibrium position if its speed is 3 m/s at the equilibrium point?
A) 0.1 m B) 0.3 m C) 3 m D) 10 m

Solution: $m = 1kg, k = 100\,N/m, v_{x=0} = 3\,m/s = v_{\max}$

$$v_{\max} = \omega A = \sqrt{\frac{k}{m}} A \Rightarrow v_{\max} = \sqrt{\frac{100N/m}{1kg}}(A) = 3m/s$$

$$\Rightarrow A = 0.3\,m$$

The answer is choice B.

16. The acceleration of a simple harmonic oscillator
A) Remains constant during its motion B) Remains non zero.
C) Attains its maximum value when its amplitude is zero.
D) Attains its minimum value when its velocity is maximum
Brief explanation: The acceleration of a simple harmonic oscillator is given as

$$a(t) = \omega^2 x(t)$$

The acceleration varies with position.
The acceleration is not constant during its motion.
The acceleration attains its maximum value when its amplitude is maximum.
The acceleration attains its minimum value when its velocity is maximum. Thus, choice D is correct.

17. A sinusoidal force with a given amplitude is applied to an oscillator. At resonance the amplitude of the oscillation is limited by:
A) the damping force B) the initial amplitude C) the initial velocity D) the force of gravity
Brief explanation: Forced oscillation's amplitude at resonance depends only on the **damping force**. choice A is the answer.

18. The position of an object moving with simple harmonic motion is given by $x = 4\cos(6\pi t)$, Where x is in meters and t is in seconds. What is the period of the oscillating system? A) 4 s B) 1/6 s C) 1/3 s D) 6πs
Solution: $x = 4\cos(6\pi t)$ T=? From

$$x = A\cos\omega t \Rightarrow A = 4m, \omega = 6\pi \Rightarrow \frac{2\pi}{T} = 6\pi \Rightarrow T = 1/3\,s$$

Choice C is correct.

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19. A mass oscillates with simple harmonic motion of amplitude A. The kinetic energy of the mass will equal the potential energy of the spring when the position is

A) $x = 0$ B) $x = \frac{A}{2}$ C) $A/\sqrt{2}$ D) $x = \frac{A}{4}$

Solution: U=K x=?

$$K + U = E \Rightarrow \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$$

$$\Rightarrow \frac{1}{2}kx^2 + \frac{1}{2}kx^2 = \frac{1}{2}KA^2$$

$$\Rightarrow 2x^2 = A^2 \Rightarrow x = \pm\frac{A}{\sqrt{2}}(Answer)$$

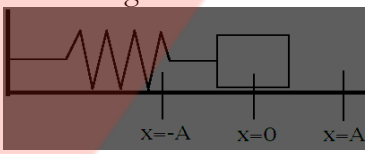
so the correct answer is C.

20. A weight suspended from an ideal spring oscillates up and down with a period T. If the amplitude of the oscillation is doubled, the period will be:

A) T B) 1.5T C) 2T D) T/2

Brief explanation: The period of simple harmonic oscillator is independent of the amplitude of oscillation. Therefore, choice A is correct.

21. A block on a horizontal frictionless plane is attached to the spring, as shown. The block oscillates on the x-axis with simple harmonic motion of amplitude A. Which of the following statements about the block is correct?



A) At x=0, its velocity is zero.

B) At x=0, its acceleration is at a maximum

C) At x=A, its displacement is at a minimum.

D) At x=A, its acceleration is maximum

Brief explanation: the $a \propto -x$, at $x = 0$ $a = 0$ and at $x = \pm A, v = 0.$ In addition, at $x = 0$, the velocity is maximum. Therefore, **choice D is correct**.

22. A block attached to a spring undergoes simple harmonic motion on a horizontal frictionless surface. Its total energy is 50 J. When the displacement is half the amplitude, the kinetic energy is: A) zero B) 12.5 J C) 25 J D) 37.5 J

Solution: $E = 50\,J,$ $x = \frac{1}{2}A$ KE =?

$$E = \frac{1}{2}kA^2 \Rightarrow \frac{1}{2}kx^2 + KE = 50\,J.\ However\ x = \frac{A}{2}$$

$$\therefore \frac{1}{2}k\left(\frac{A}{2}\right)^2 + KE = 50J$$

$$\Rightarrow \frac{\frac{1}{2}kA^2}{4} + KE = 50J \quad Again\ remember\ that\ \frac{1}{2}kA^2 = 50\,J$$

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$$\Rightarrow \frac{50J}{4} + KE = 50J$$
$$\Rightarrow KE = 50J - 12.5J$$
$$\Rightarrow KE = 37.5J\,(Answer)$$

so the correct answer is C.

23. A 0.35 kg mass attached to the end of a spring oscillates 2.5 times per second with an amplitude of 0.15 m. which of the following is true about motion of the mass?

A) the velocity when it passes the equilibrium is 2.355 m/s.

B) the total energy of the system is 97 J

C) the velocity when it is 0.1 m from the equilibrium is 3 m/s

D) the acceleration when it is 0.1m from equilibrium is 25 m/s^2

Brief explanation and solution:

The velocity when it passes through the equilibrium is the maximum velocity: $v_{max} = \omega A = 2 = 2.355 m/s$. The total energy of a simple harmonic oscillator is $E = \frac{1}{2} kA^2 = \frac{1}{2} mv_{max}^2 = 0.97 J$. The velocity of the oscillator an any point specifically at

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x=0.1m is $= \omega \sqrt{\square^2 + \square^2} = 1.755 m/s$. The answer is A.

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Unit 9: Review and Summary on Wave Optics

9.1. Short notes on Wave optics

- **Wave front** is an imaginary line joining points of a traveling wave that are in phase.
- **A ray** is an imaginary line along the direction of travel of the wave.
- Huygens' principle states that:
- Every point of a wave front may be considered as the **source of secondary wavelets** that spread out in all directions with a speed equal to the speed of propagating waves.
- Newton's corpuscular theory assumed that light consists of a stream of particles called corpuscles.

Interference of light and interference pattern

- To observe **sustained interference pattern** between two sources of light:

The sources must be ***coherent***, which means that:

- The waves they emit must ***maintain a constant phase*** with respect to one another. The waves do not have to be in phase; however, their phase relationship must be constant.
- The waves must be the ***same type of wave***.
- The waves must have ***identical wavelengths and frequency*** **(**the light waves must be ***monochromatic*****)** otherwise, a beat occurs.
- An interference is the result of a path difference and so a phase difference between different rays of light.
- For constructive interference, the path difference $\Delta x = m\lambda$. For destructive interference, the path difference $\Delta = \left(m + \frac{1}{2}\right)\lambda$.
- The interference pattern produced by Young's double slits comprises a series of equal width maxima and minima known as fringes.
- The vertical positions of the bright and dark fringes are given by: and $y_{bright} = m\frac{\lambda}{d}, m = 0, \pm1, \pm2\ldots\ldots$ $y_{dark} = \left(+\frac{1}{2}\right)\frac{\lambda L}{d} \ldots\ldots\ldots m = 0, \pm1, \pm2\ldots\ldots$
- and the fringe spacing is given by $\Delta y = \frac{\lambda L}{d}$ ……

Diffraction of light and diffraction pattern

- Single slit causes a diffraction pattern, because every point in the slit serves as a source of a wave.
- The first diffraction minima occur at an angle $a\sin\theta = \lambda$.
- The separation between minima widens when the wavelength (λ) increases or the slit width(a) decreases.
- When the slit is very narrow the first minima is far away and one has continuous distribution of light.
- If $a < \lambda$ no minima are observed, the whole screen is full of bright fringe.
- Unlike the interference pattern, the central maxima in the diffraction pattern is twice the other maxima. $W_{central} = 2\frac{\lambda L}{a}$ where a is the slit width.

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Diffraction grating

- The location of the maxima does not depend on the number of slits, N. However, the maxima becomes sharper and more intense as N increases.
- The greater the number of illuminated slits the sharper the maximum and the narrower the width of the bright fringes.
- The maximum number of orders (m) produced on one side of the central peak is $m = \frac{d}{\lambda}$ and round down to the nearest whole number.

Thin film Interference.

- The varied colors observed when white light is observed on thin layers of oil on water or the thin surface of a bubble is due to the phenomenon called ***thin film interference***.
- Thin film interference is due to the interference of light waves reflecting off the top surface of a film with those that have reflected off the bottom surface of the film.

Equations (m=0,1,….)	**1 phase reversal due to reflection**	**0 or 2 phase reversal due to reflection**
$2nt = \left(m + \frac{1}{2}\right)\lambda$	Constructive	Destructive
$2nt = m\lambda$	Destructive	Constructive

9.2 Topics Related Questions on Unit 10

I. Choose the best answer from the given alternatives.

1.A two-slit interference pattern is formed using monochromatic laser light that has a wavelength of 640 nm. At the second maximum from the central maximum, what is the path-length difference between the light coming from each of the slits? A) 640 nm B) 320 nm C) 960 nm D) 1280 nm

Brief explanation and Solution:

λ=640nm. $\delta = \Delta L = ?$ For bright fringe $\delta = m\lambda \quad where \quad m\,is\,called\,the\,order\,number$

At the second maximum, m=2. Therefore, $\Delta L = \delta = 2(640nm) = 1280nm$ .Choice D is correct.

2.A two-slit interference pattern is formed using monochromatic laser light that has a wavelength of 450 nm. What happens to the distance between the first maximum and the central maximum as the two slits are moved closer together?

A) The distance increases. B) The distance decreases.

C) The distance remains the same. D) None of the above.

Brief explanation: The distance between two successive bright fringes is given by $\Delta y = \frac{\lambda L}{d}$. Therefore, as **d** decreases **Δy** increases. Choice A is correct.

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3A two-slit interference pattern is formed using two different monochromatic lasers, one green and one red. Which color light has its first maximum closer to the central maximum?

A) green B) red C) Both maxima are at the same location. D) no maxima

Brief explanation: The fringe spacing (between maximum fringes) is given by; $\Delta y = \frac{\lambda L}{d}$.

The distance between the 1st maximum and the central maximum depends on the wavelength of the laser. Therefore, since $\lambda_{green} < \lambda_{red}$ We can conclude that $\Delta y_{green} < \Delta y_{red}$. *The first maximum for green light is closer to the central maximum than it is for the red light.* (Choice A is correct.)

4. Young's double-slit experiment is performed with 590 nm light and a distance of 2 m between the slits and the screen. The tenth interference minimum is observed 10 mm from the central maximum. What is the spacing of the slits?

A) 1.54 mm B) 1.12 mm C) 2.24 mm D) 2.58 mm

Solution: λ=590 nm, L= 2m $y_{10} = 10mm$ d =? The location of the minimum from the central maximum is given by $y_{\min imum} = \left(m + \frac{1}{2}\right)\frac{\lambda L}{d}$. However, remember that as the first minimum occurs at m=0 the 10th minimum occurs at m=9

$$\Rightarrow y_{10} = \left(9 + \frac{1}{2}\right)\frac{\lambda L}{d} \Rightarrow d = \left(\frac{19}{2}\right)\frac{\lambda L}{y_{10}} \Rightarrow \left(\frac{19}{2}\right)\frac{(590x10^{-9}m)(2)}{10x10^{-3}m} = 1.12mm$$

(choice B is correct)

5. In Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance D must be changed to: A) D/2 B) D/$\sqrt{2}$

C) D $\sqrt{2}$ D) 2D

Solution: Given $d_2 = 2d, \Delta y_2 = \Delta y_1$ Required: $D_2 = ?$ $\Delta y_2 = \Delta y_1 \Rightarrow \frac{\lambda D}{d} = \frac{\lambda D_2}{2d} \Rightarrow D_2 = 2D$.

Choice D is correct.

6. In Young's double-slit experiment, the slit separation is doubled. This results in:

A) an increase in fringe intensity B) a decrease in fringe intensity

C) a halving of the wavelength D) a halving of the fringe spacing

Brief explanation: doubling in slit separation results **in halving in fringe spacing**. Choice D is correct

7. A wave front is a surface of constant:

A) phase B) frequency C) wavelength D) amplitude

Brief explanation: a wave front is a point at which the phase of vibration of the wave is the same. Choice A is correct.

8. Waves from two slits are in phase at the slits and travel to a distant screen to produce the second minimum of the interference pattern. The difference in the distance traveled by the waves is:

A) half a wavelength B) a wavelength

C) Three halves of a wavelength D) two wavelengths

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Brief explanation: For interference minimum, the path length difference, ΔL is related with the wavelength λ as $\Delta L = \delta = \left(m + \frac{1}{2}\right)\lambda$. The second minimum occurs at $m = 1$ $\Rightarrow \Delta L = \left(\frac{3}{2}\right)\lambda$.

Choice C is correct

9. Monochromatic light, at normal incidence, strikes a thin film in air. If λ denotes the wavelength in the film, what is the thinnest film in which the reflected light will be a maximum?

A) λ /4 B) λ/ 2 C) 3 λ/4 D) λ

Solution: $\lambda_n = \lambda$ and there is only **one phase reversal** as it is going from $air \rightarrow film \rightarrow air$

$\Rightarrow for\ constructive \quad 2t = \left(m + \frac{1}{2}\right)\lambda_n \Rightarrow 2t = \left(m + \frac{1}{2}\right)\lambda$.

The thinnest film corresponds to $m = 0$. Choice A is correct

10. A thin film of acetone (n =1.25) coats a thick glass plate (n = 1.50).White light is incident normal to the film. In the reflections, fully destructive interference occurs at 600 nm and fully constructive interference at 700 nm. Calculate the thickness of the acetone film. A) 512 nm B) 240 nm C) 640 nm D) 840 nm

Solution: Given $n_{film} = 1.25,\ \lambda_{destructive} = 600nm, \lambda_{constructive} = 700nm$ Required t=? The light goes from the $air \rightarrow acetone \rightarrow glass \rightarrow$ in increasing order of n. The light executes two-phase reversals. Therefore,

<u>for destructive interference</u>; <u>for constructive interference</u>

$$\Rightarrow 2t = \left(m + \frac{1}{2}\right)\frac{\lambda_{destructive}}{n} \Rightarrow 2t = m\frac{\lambda_{constructive}}{n}$$

$$\Rightarrow m\lambda_{constructive} = m\lambda_{destructive} + \frac{\lambda_{destructive}}{2}$$

$$\Rightarrow m\left(\lambda_{constructive} - \lambda_{destructive}\right) = \frac{\lambda_{destructive}}{2}$$

$$\Rightarrow m(700nm - 600nm) = 300nm \Rightarrow m = 3$$

Therefore, substitute m in one of the above equations

$$2t = 3\frac{700nm}{1.25} \Rightarrow t = \frac{2100nm}{2.5} = 840nm.$$ Choice D is correct

11. A monochromatic light with a wavelength of λ = 600 nm passes through a single slit which has a width of 0.8 mm. What is the distance between the slit and the screen to be located if the first minimum in the diffraction pattern is at a distance 1 mm from the center of the screen?

A) 4.66 mm B) 2.33 mm C) 1.33 mm D) 4.33 mm

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Solution λ = 600 nm, a=0.8 mm $y_{m=1} = 1mm$ L=?

the first diffraction minima correspond to m=1

then $\frac{y}{L}=\frac{\lambda}{a}\Rightarrow L=\frac{ya}{\lambda}\Rightarrow L=\frac{(1x10^{-3}m)(0.8x10^{-3})}{600x10^{-9}m}=1.33m$ choice C is correct

12. A beam of monochromatic light is diffracted by a slit of width 0.600 mm. The diffraction pattern forms on a wall 1.30 m beyond the slit. The width of the central maximum is 2.00 mm. Calculate the wavelength of the light. A) 600 nm B) 462 nm C) 544 nm D) 700 nm

Solution: $a=0.6mm, L=1.3m, w=2mm$ λ=?

$w=\frac{2\lambda L}{a}\Rightarrow\lambda=\frac{wa}{2L}\Rightarrow\lambda=\frac{2x10^{-3}(6x10^{-4})}{2x1.3}\Rightarrow\lambda=4.6x10^{-7}m$. Choice **B** is correct

13. A screen is placed 50.0 cm from a single slit that is illuminated with light of wavelength 680 nm. If the distance between the first and third minima in the diffraction pattern is 3.00 mm, what is the width of the slit? A) 0.46 mm B) 0.23 mm C) 0.54 mm D) 0.34 mm

Solution: L=50 cm λ=680 nm $\Delta y=y_3-y_1=3x10^{-3}m$ a=?

$y_3-y_1=\frac{3L\lambda}{a}-\frac{L\lambda}{a}\Rightarrow y_3-y_1=\frac{2\lambda L}{a}$

$\Rightarrow a=\frac{2\lambda L}{y_3-y_1}\Rightarrow a=\frac{2(0.5m)(680x10^{-9})}{3x10^{-3}m}=0.23mm$ Choice B is correct

14. A diffraction grating 20 mm wide has 6000 rulings (slits). What is the distance d between adjacent rulings (slits)? A) 1.33 μm B) 2.66 μm C) 2 μm D) 3.33 μm

Solution: $w=20mm, N=6000$ d=?

The width of the grating is $w=Nd\Rightarrow d=\frac{w}{N}\Rightarrow d=\frac{20x10^{-3}}{6000}\Rightarrow d=3.33\mu m$. Choice D is correct

15. A grating has 600 rulings/ mm and is 5.0 mm wide and λ = 500 nm. How many higher orders of maxima can be seen? A) 3 B) 6 C) 4 D) 5

Solution: $\frac{Number\ of\ ruling}{mm}=600lines/mm, w=5mm$ m=?

we take the order $m=\frac{d}{\lambda}$ and *round down to the nearest whole number,*

$slit\ separation(d)=\frac{1}{600line/mm}=1.67x10^{-3}mm$ *Therefore,* $\frac{d}{\lambda}=\frac{1.67x10^{-3}}{500x10^{-9}}=3.34$ *rounding this number down* gives 3. Therefore, A is correct .

16. A wave front is:

A) A line that represents the direction of propagation of light.

B) The locus of all points of a traveling wave that are in phase.

C) The minimum distance between two points that are in phase.

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D) The number of waves crossing a given plane in a given time.

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17. What happens if the monochromatic light used in Young's double slit experiment is replaced by white light? A) no fringes are observed B) all bright fringes become white
C) all bright fringes have colors between violet and red
D) only the central fringe is white, all other fringes are colored.
Brief explanation: if the light used in Young's double slit experiment is not monochromatic, the central fringe will be white and the rest contains a range of colors. Choice D is correct.

18. In Young's double slit experiment both the separation between the slit and the distance between the slits and the screen are halved then what is the fringe width?
A) halved B) unchanged C) zero D) doubled
Solution: $d_2 = 2d, L_2 = 2L \quad w_2 = ?$

$$w_2 = \frac{\lambda L_2}{d_2} \Rightarrow w_2 = \frac{\lambda(2L)}{2d} \Rightarrow w_2 = w$$

Choice B is correct.

19. A wave traveling from a medium of index of refraction n_1 toward a medium of index of refraction n_2 undergoes partly transmission and partly reflection. If n_2 is greater than n_1 Which one of the following statements is correct?

A) The speed of the wave in the medium with refractive index of n_1 is smaller than n_2
B) The incident and the reflected waves are in phase
C) The angle of reflection is the same as the angle of incidence
D) The refraction angle is less than the incidence angle.
Brief explanation: As waves travel from less dense to denser medium, their speed decreases and their phase shifts by λ/2. And the angle of incidence and reflection are equal. However, the ray bends towards the normal and the angle of refraction will be less. Therefore, ***choice D is correct***.

20. A viewing screen is separated from a double slit by 4.80 m. The distance between the two slits is 0.30 mm. monochromatic light is directed toward the double slit and forms an interference pattern on the screen. The first dark fringe is 4.50 cm from the center line on the screen. What is the wavelength of the light?
A) 1250 nm B) 1875 nm C) 2500 nm D) 5625 nm
Solution: L= 4.80 m, d=0.3 mm, $y_{1\,dark} = 4.50cm$ λ=?

$$y_{dark} = \left(m + \frac{1}{2}\right)\frac{\lambda L}{d} \Rightarrow y_{1\,dark} = \frac{\lambda L}{2d}$$

$$\Rightarrow \lambda = \frac{2dy_{1\,dark}}{L} \Rightarrow \lambda = \frac{2(3x10^{-4}m)(4.5x10^{-2}m)}{4.8}$$

$\lambda = 5625nm$. Therefore, ***choice D is correct***.

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Unit 10: Review and summary on Electrostatics

10.1 Short notes on Electric charge and Coulomb's law.

- **Force** of Interaction between two stationary point charges is directly proportional to the product of the charges, inversely proportional to the square of the distance between them and acts along the straight line joining the two charges. $F = k\frac{Q_1 Q_2}{r^2}$
- Gravitational forces are always attractive in nature while electrostatic forces may be attractive or repulsive.
- Gravitational constant of proportionality does not depend upon the medium; the electrical constant of proportionality depends upon the medium.
- Electrostatic forces are extremely large as compared to gravitational forces. However, both electrostatic and gravitational forces are conservative forces.
- Electric field is a region around a point charge where a second charge experiences electrical force.
- The electric field intensity at distance r from a point charge is $\vec{E} = K\frac{Q}{r^2}$
- Gauss law states that the electric flux through any closed surface is directly proportional to the enclosed electric charge.
- The flux through an area is proportional to the number of electric field lines passing through that area.

$$\phi_E = EA\cos\theta$$

- The electric field between two parallel plates is uniform and the field strength may be calculated using $E = \frac{\phi}{\varepsilon} = \frac{}{d}$.
- **Dipole** is a system of two equal and opposite charges at finite & fixed distance.
- There are two types of electric dipoles 1. Permanent dipoles. Examples: H_2O, HCl
  2. Induced dipoles are dependent on external electric fields. The atoms only form a dipole while the electric field is present. An electric dipole moment is given by $P = qd$
- When a dipole is placed within an electric field, the net force acting on it is zero. However, the net torque acting on it turns the dipole moment towards the electric field intensity.

Electric Potential.

- The potential energy per unit charge at a point in an electric field is called the **electric potential** V (or simply the **potential**) at that point. Thus, $V = \frac{}{}$.

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- The electric potential around a point charge is $V = \frac{kq}{r}$
- If a charge moves from a to b in ***uniform electric field*** $V_b - V_a = -Ed$. Spontaneously, positive charges move towards decreasing electric potential and negative charges move toward increasing electric potential.
- The change in electric potential is $\Delta V = \frac{\Delta U}{q}$
- An equipotential surface is one on which all points are at the same potential. That is, the potential difference between any two points on the surface is zero.
- No work is required to move a charge from one point to the other at equal potential.

Capacitors and Dielectrics.

- A capacitor is a device used to store charge and electrical energy.
- The amount of charge, Q acquired by each plate is proportional to the potential difference between the plates.
- The capacitance of a capacitor is given by $C = \frac{Q}{V}$
- The capacitance of a capacitor depends on the geometry of the two conductors:
  - Size of the conductor
  - Shape of the conductor
  - Relative position between the conductors
  - Materials that separate them
- The capacitance of a parallel plate capacitor is $C = \epsilon_0 \frac{A}{d}$.
- it is found experimentally that if the dielectric fills the space between the two conductors, it increases the capacitance by a factor K which is known as the dielectric constant $C = k\epsilon_0 \frac{A}{d}$

Combination of capacitors

- When capacitors are connected in parallel $C_{eq} = C_1 + C_2 + C_3 \dots$
- When capacitors are connected in series $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots$
- The equivalent capacitance of capacitors in parallel is always greater than the larger capacitance in the circuit.
- The equivalent capacitance of capacitors in series is always less than the least of the capacitance in the circuit.

Energy stored in a capacitor

- Work must be done to charge a capacitor, and ***at least some of this work is stored as electrostatic potential energy.*** This potential energy is the energy stored in the capacitor. And is given by

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$U = \frac{1}{2}QV = \frac{Q^2}{2C} = \frac{1}{2}CV^2$

- We can think of the energy stored in a capacitor as energy stored in the electric field, called electrostatic field energy and is given as $U = \frac{1}{2}\varepsilon_0 E^2$
- The energy per unit volume is called the **energy density** u_e . The energy density in an electric field of strength is thus $U = \frac{1}{2}\varepsilon_0 E^2$

Charging and Discharging capacitor

- If a capacitor is charged with a battery through a resistor of resistance *R*, the charge on the capacitor and the current in the circuit vary in time according to the expressions

$Q(t) = Q_0\left(1 - e^{-\frac{t}{RC}}\right)$ and $I(t) = I_0\left(e^{-\frac{t}{RC}}\right)$

- If a charged capacitor is discharged through a resistor of resistance *R*, the charge and current decrease exponentially in time according to the expressions $Q(t) = Q_0 e^{\left(-\frac{t}{RC}\right)}$ and $I(t) = I_0 e^{-\frac{t}{RC}}$

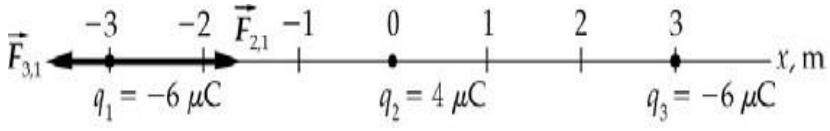
10.2 Topics Related Questions on Unit 11

I. Choose the best answer from the given alternatives.

1. Three-point charges are on the axis: $q_1 = -6\mu C$ is at $x = -3m, q_2 = 4\mu C$ is at $x = 0, and\ q_3 = -6\mu C$ is at $x = 3m$. Find the net electric force on q_1 .

A) $1.5x10^{-2}$ N to the right B) $1.5\ x10^{-2}$N to the left C) $3x10^{-2}$ N to the right D) $3x10^{-2}$N to the left

Brief explanation: This example illustrates how to use the super position principle in solving electrostatic force on more than 2 charge configurations



$F_{21} = k\frac{q_2 q_1}{r_{21}^2}$ to the right. And $F_{31} = \frac{kq_3 q_1}{r_{31}^2}$ to the left $\therefore \overrightarrow{F_{net}} = \vec{F}_{21} + \vec{F}_{31} \Rightarrow \overrightarrow{F_{net}} = \vec{F}_{21} - \vec{F}_{31}$

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$$\Rightarrow kq_1\left(\frac{q_2}{r_{21}^2}-\frac{q_3}{r_{31}^2}\right)\Rightarrow 9x10^9\ N.m^2/C^2\left(6x10^{-6}C\right)\left(\frac{4x10^{-6}C}{(-3m)^2}-\frac{6x10^{-6}C}{(6m)^2}\right)$$

$$\Rightarrow \overrightarrow{F_{net}}=\left(9x10^9\ N.m^2/C^2\right)\left(6x10^{-6}C\right)\left(\frac{10}{36}x10^{-6}C\right)\Rightarrow \overrightarrow{F_{net}}=1.5x10^{-2}\,N\ to\ the\ right$$

2. An electron with a speed of $3x10^6$ m/s moves into a uniform electric field of magnitude $1x10^3$ N/C. The field lines are parallel to the electron's velocity and pointing in the same direction as the velocity. How far does the electron travel before it is brought to rest?

   A) 2.6 m B) 5.2 m C) 3.4 m D) 5.4 m

   Brief explanation and solution: From Newton's second law, the acceleration of the electron is

$$a_x=\frac{F_x}{m}\Rightarrow a_x=\frac{qE_x}{m}$$

$$\Rightarrow a_x=\frac{\left(-1.6x10^{-19}\right)\left(1x10^3\,N/C\right)}{9.11x10^{-31}kg}$$

$$\Rightarrow a_x=1.76x10^{14}\,m/s^2$$

And since the net force and hence the acceleration is constant, we can use the kinematics equation to find the stopping distance.

$v_x^2=v_{0x}^2+2a_x(\Delta x)$ When the electron stops $v_x=0$

$$\Rightarrow(\Delta x)=\frac{-v_{0x}^2}{2a_x}\Rightarrow \Delta x=\frac{-\left(3x10^6\,m/s\right)^2}{2\left(-1.76x10^{14}\,m/s^2\right)}\Rightarrow \Delta x=2.56\,cm$$

choice A is correct

3. Consider Gauss's law: $\sum E.dA=\frac{Q}{\varepsilon_0}$. Which of the following is true?

   A) E must be the electric field due to the enclosed charge

   B) If q = 0, then E = 0 everywhere on the Gaussian surface

   C) If the three particles inside have charges of +q, +q, and −2q, then the integral is zero

   D) If a charge is placed outside the surface, then it cannot affect E at any point on the surface **Brief explanation:** Remember the points explained before that E on the left side of Gauss's law is not necessarily due only to the charge Q_{encl} that appears on the right.

   - If q=0, then E may not be zero since it's not only dependent on the enclosed charge q
   - If charge is placed outside your Gaussian surface the E may be affected because the electric field is not only dependent on the enclosed charge.
     If the enclosed charges are equal and opposite the Q_{encl}=0 then the integral is zero
     Therefore, **choice C is correct**

4. Choose the INCORRECT statement:

   A) Gauss' law can be derived from Coulomb's law

   B) Gauss' law states that the net number of lines crossing any closed surface in an outward direction is proportional to the net charge enclosed within the surface

   C) Coulomb's law can be derived from Gauss' law and symmetry

   D) Gauss' law applies to a closed surface of any shape

   E) According to Gauss' law, if a closed surface encloses no charge, then the electric field must vanish everywhere on the surface.

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Brief explanation: Although gauss law is more general, it can be derived from coulomb's law and vice versa. The electric field is not only due to the enclosed charge. Therefore, choice **E is incorrect.**

5. The torque exerted by an electric field on a dipole is:
   A) parallel to the field and perpendicular to the dipole moment
   B) parallel to both the field and dipole moment
   C) perpendicular to both the field and dipole moment
   D) parallel to the dipole moment and perpendicular to the field
6. In a certain region of space, the electric potential increases uniformly from east to west and does not vary in any other direction. The electric field:
   A) points east and varies with position B) points east and does not vary with position
   C) points west and varies with position D) points west and does not vary with position

   Brief explanation: The electric field is directed along the direction of decreasing potential. Therefore, the electric field must be directed along the east direction. Choice A is correct. **Brief explanation:** the torque acting on an electric dipole in uniform electric field is given by $\tau = \vec{P} x \vec{E}$ Therefore, the torque is perpendicular to both P and E. **choice C is correct.**
7. An electron moves from one point to another point, in the direction of a uniform electric field. During this displacement:
   A) the work done by the field is positive and the potential energy of the electron-field system increases
   B) the work done by the field is negative and the potential energy of the electron-field system increases
   C) the work done by the field is positive and the potential energy of the electron-field system decreases
   D) the work done by the field is negative and the potential energy of the electron-field system decreases

   Brief explanation: When an electron moves in the direction of an electric field the electrostatic force is opposite to its displacement $\Rightarrow W_{field} < 0$ From $W_{field} = -\Delta U$

   $\Rightarrow -W_{field} = -\Delta U \Rightarrow \Delta U > 0$

   Therefore, the potential energy increases. **Choice B is correct**.

   The electric field is determined from the potential using the equation $E = -\frac{\Delta V}{\Delta x}$

   The electric field is always directed in ***the direction of decreasing potential.*** Therefore, ***E is directed east and does not vary with position***. Choice B is correct.
8. The electric potential at x =3.0 m is 120 V, and the electric potential at x =5.0 m is 190 V. What is the electric field in this region, assuming it's constant? A) 140N/C B) -140N/C C) 35N/C D -35N/C

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Solution: In a uniform electric field $E = -\frac{\Delta V}{\Delta x}$

$\Rightarrow E_x = -\frac{(190-120)}{5-3}$

$\Rightarrow \underline{\underline{E_x = -35N/C.}}$

9. Two uncharged capacitors have capacitances C_0 and $2C_0$ respectively, and are connected in series. This series combination is then connected across the terminals of a battery. Which of the following is true?

A) The capacitor $2C_0$ has twice the charge of the other capacitor.

B) The voltage across each capacitor is the same.

C) The energy stored by each capacitor is the same.

D) the equivalent capacitance is $2C_0/3$

Brief explanation: When two or more capacitors are connected in series, $Q_1 = Q_2 = Q_n$ and the potential drop across each depends on the capacitance of each. For two capacitors connected in series the $C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{(C_0)(2C_0)}{3C_0}$

$\Rightarrow \underline{\underline{C_{eq} = 2C_0/3.\ Choice\ D\ is\ the\ answer}}$

10. Capacitors A and B are identical. Capacitor A is charged so it stores 4 J of energy and capacitor B is uncharged. The capacitors are then connected in parallel. The total stored energy in the capacitors is now: A) 16 J B) 8 J C) 4 J D) 2 J

Solution: Initially $U_A = 4J\ and\ U_B = 0, C_1 = C_2 = C$

The energy stored by the capacitors after they are connected in parallel=?

$U_A + U_B = 4J$

$\Rightarrow \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2 = 4J.\quad However, C_1 = C_2 = C$ and since they are connected in parallel,

$V_1 = V_2 = V$

$\Rightarrow 2\left(\frac{1}{2}CV^2\right) = 4J \qquad \therefore \underline{\underline{U_1 = U_2 = 2J.}}$

11. An air-filled parallel-plate capacitor has a capacitance of 1.3 pF. The separation of the plates is doubled, and wax is inserted between them. The new capacitance is 2.6 pF. Find the dielectric constant of the wax.

A) 2 B) 4 C) 6 D) 8

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Solution: $C_0 = 1.3pF$, $d = 2d_0$ and $C = 2.6pF$ K=?

$$C = k\frac{\varepsilon_0 A}{d}$$

After a dielectric is inserted

$$\Rightarrow C = k\frac{\varepsilon_0 A}{2d_0} \Rightarrow C = \frac{k}{2}C_0$$

$$\Rightarrow 2.6pF = \frac{k}{2}(1.3pF)$$

$$\Rightarrow \underline{\underline{k = 4 \quad Answer}}$$

12. What is the electric potential energy of two electrons separated by 2 nm?

Solution: The potential energy due to two systems of charges is written as $U_{21} = V_1 e_2$ Assuming as if e_2 is inserted in the field of e_1 (the first electron is acting as a source charge)

$$\Rightarrow U_{21} = \left(\frac{Ke_1}{d}\right)e_2 \Rightarrow U_{21} = \frac{ke^2}{d}$$

$$\Rightarrow U_{21} = \frac{(9x10^9)(1.6x10^{-19})^2}{2x10^{-9}} \Rightarrow \underline{\underline{U_{21} = 1.15x10^{-19}J.}}$$

13. Suppose an electron in a cathode ray tube is accelerated from rest through a potential difference $V_b - V_a = V_{ba} = +5000$ V. (a) What is the change in electric potential energy of the electron? (b) What is the speed of the electron? ($m = 9.1 \times 10^{-31}$ kg) as a result of this acceleration?

Solution: The change in potential energy of the electron is

a) $\Delta U = qV_{ba}$

$$\Rightarrow \Delta U = (-1.6x10^{-19})(5000V)$$

$$\Rightarrow \underline{\underline{\Delta U = -8x10^{-16}J.}}$$

The minus sign indicates that the potential energy decreases.

b) The potential energy lost by the electron becomes kinetic energy

$$\Delta KE = -\Delta U \Rightarrow \frac{1}{2}mv^2 = -q(V_b - V_a)$$

$$\Rightarrow v = \sqrt{-\frac{2qV_{ba}}{m}}$$

$$\Rightarrow \underline{\underline{v = 4.19x10^7 m/s.}}$$

14. Three capacitors of capacitances, 8μF, 12μF, and 24μF are connected (a) in series and then (b) in parallel. What is the ratio of the equivalent capacitance in case (a) to that in case (b)?

A) 1:11 B) 11:1 C) 1:1 D) 1:3

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Solution: Capacitors: $C_1 = 8\mu F,\ C_2 = 12\mu F,\ C_3 = 24\mu F$ $\qquad \frac{C_{series}}{C_{parallel}} = ?$

$$\frac{1}{C_{series}} = \frac{1}{8\mu F} + \frac{1}{12\mu F} + \frac{1}{24\mu F}$$

$$\Rightarrow \frac{1}{C_{series}} = \frac{6\mu F + 4\mu F + 2\mu F}{48\mu F^2} \Rightarrow \underline{\underline{C_{series} = 4\mu F}}$$

$$C_{parallel} = C_1 + C_2 + C_3 = 8\mu F + 12\mu F + 24\mu F \Rightarrow \underline{\underline{C_{parallel} = 44\mu F}}$$

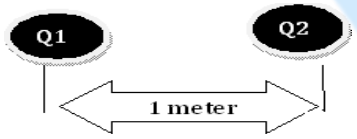
$$\therefore \frac{C_{series}}{C_{parallel}} = \frac{4\mu F}{44\mu F} \Rightarrow \frac{C_{series}}{C_{parallel}} = 1:11.$$

Answer is A

15. What is the potential energy of two equal positive point charges 1μC each held 1 m apart in air?

A) 1 J B) 1 eV C) $9x10^{-3}$ J D) Zero

Solution: $Q_1 = Q_2 = 1\mu C$



$$\Rightarrow U_{21} = V_1 Q_2$$

$$\Rightarrow U_{12} = V_2 Q_1$$

However, $U_{21} = U_{12} = \frac{kQ_1Q_2}{d}$

$$\Rightarrow U_{12} = U_{21} = U \Rightarrow U = \frac{kQ^2}{d} \Rightarrow U = \frac{(9x10^9)(1x10^{-12})}{1m}$$

$\Rightarrow \underline{\underline{U = 9x10^{-3}J}}$. Choice C is correct.

16. One of the following is NOT characteristics of electric field.

A) an electric field is a region around a charged object where another charged object will experience a force.

B) lines of electric field have a direction which moves away from negative and toward positive.

C) the direction of electric field is the direction of force acting on a small positive test charge.

D) lines of electric flux do not cross over each other.

Brief explanation: The electric field lines always ***emanate from positive*** charge and ***terminate on negative charge.*** **Therefore,** choice B is not the characteristics of electric filed.

17. When a potential difference of 150 V is applied to the plates of a parallel plate capacitor, the plates carry a surface charge density of 30 $\frac{nC}{cm^2}$. What is the spacing between the plates?

A) 2.24μm B) 5.32μm C) 12.24μm D) 4.42μm

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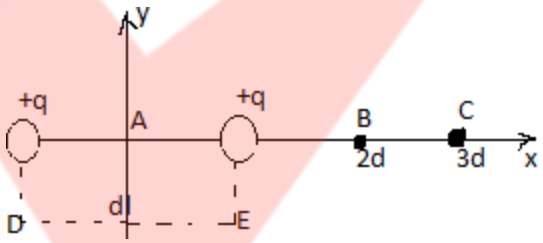
Solution: V=150 V, $\delta = 30\frac{nC}{cm^2}$ d=?

$$C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d} \Rightarrow \frac{Q}{A} = \frac{\varepsilon_0 V}{d} \Rightarrow \delta = \frac{\varepsilon_0 V}{d}$$

$$\Rightarrow d = \frac{\varepsilon_0 V}{\delta} \Rightarrow d = \frac{8.85x10^{-12}(150V)}{30x10^{-9}C/10^{-4}m^2}$$

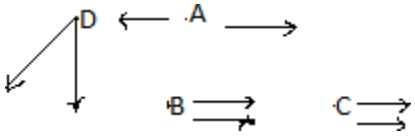
$$\Rightarrow \underline{\underline{d = 4.42\mu m}}.. \text{ Choice D is correct.}$$

18. 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



A) A B) B C) C D) D

Solution: At point A The electric field strength due to the two charges are equal and oppositely directed. The net may add up to zero. At point B and point C The electric field vectors due to the two charges are directed towards the right. The net cannot be zero. At point D The electric field is shown in the diagram. The net cannot be zero. Therefore, the point where the electric field is Minimum is point A. ***Thus, choice A is correct.***



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Unit 11: Review and Summary on Steady Electric current and Circuit properties

11.1 Short Notes on on Steady Electric current and Circuit properties

Electric current and ohm's law

- The electric current I in a conductor is defined as $I = _$.
- Conductivity is reciprocal of resistivity or resistivity is reciprocal of Conductivity. Equations that relate the resistivity ϱ and conductivity σ of a material $\varrho = \frac{1}{c}$
- Ohms Law states that if a conductor is maintained at constant temperature, the current through the conductor is directly proportional to the p.d across the ends of the conductor.
- The resistance R of a conducting wire of length L and uniform cross sectional area A is $R = \varrho _$, where A is the cross-sectional area.
- Microscopically, electric current is defined as $I = nqv_d A$
- The current density is directly proportional to the applied electric field across the terminals of the conductor. And mathematically given as $\vec{J} = \sigma \vec{E}$

Terminal potential difference, electromotive force and internal resistance

- The ***emf*** of an emf device is the work per unit charge that the device does in moving charge from its low-potential terminal to its high-potential terminal.
- An **ideal emf device** is one that lacks any internal resistance to the internal movement of charge from terminal to terminal
- The potential difference between the terminals of an ideal emf device is equal to the emf of the device.

$$\Rightarrow \varepsilon = V_{ab} = ter\min al\ \ p.d$$

- $\Rightarrow \varepsilon = V_{ab}$ } when either the battery is ***ideal*** or when ***there is no current*** through the real source of emf.
- For real batteries with internal resistance, $V_{ab} = \varepsilon - Ir$

Combination of resistors

1) Series combination

- $R_{eq} = R_1 + R_2 + R_3$. Equivalent resistance is greater than the maximum value of resistance in the combination

2) Parallel combination

- $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$. Equivalent resistance is smaller than the minimum value of resistance in the combination.

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Electrical Energy and Power

♦ If a potential difference V is maintained across an electrical device, the **power,** or rate at which energy is supplied to the device, is $P = IV$ and the **power delivered to a resistor** can be expressed as

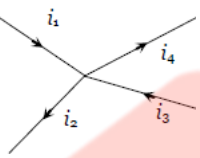
$$P = I^2 R = \frac{V^2}{R}$$

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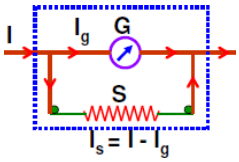
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Kirchhoff's Laws

- **Kirchhoff's first law:** This law is also known as junction rule or current law (*KCL*).
- According to it the algebraic sum of currents meeting at a junction is zero *i.e.* $\sum I = 0$.
- In a circuit, at any junction the sum of the currents entering the junction must equal the sum of the currents leaving the junction. $i_1 + i_3 = i_2 + i_4$

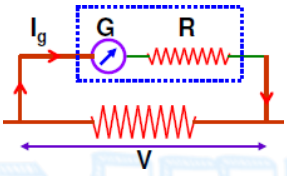


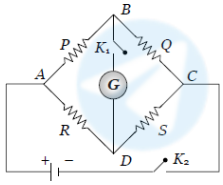
- This law is simply a statement of "*conservation of charge*" as if current reaching a junction is not equal to the current leaving the junction, charge will not be conserved.
- **Kirchhoff's second law :** This law is also known as loop rule or voltage law (KVL) and according to it "the algebraic sum of the changes in potential in complete traversal of a closed loop is zero", *i.e.* $\sum V = 0$
- **This** law represents "*conservation of energy*" as if the sum of potential changes around a closed loop is not zero, unlimited energy could be gained by repeatedly carrying a charge around a loop



Different measuring instruments

- Galvanometer can be converted into ammeter by shunting it with a very small resistance in parallel given by: $R_s = \left(\frac{I_g}{I - I_g}\right)\Omega$
- Galvanometer can be converted into voltmeter by connecting it in series with a very high resistance given by: $R = \frac{V}{I_g} - R_g$ Ω





- Wheatstone bridge is an arrangement of four resistance which can be used to measure one of them in terms of rest. In the balanced condition the potential difference between B and D becomes zero and $\frac{P}{Q} = \frac{R}{S}$.
- A potential divider circuit consists of two components put in series across a voltage source. They divide the voltage into smaller parts. $\frac{V_2}{R_2} = \frac{V_{source}}{R_1 + R_2}$.

11.2 Topic Related Questions on Unit 12

I- Choose the correct answer for the following questions.

1. Conduction electrons move to the right in a certain wire. This indicates that:

A) the current density and electric field both point right
B) the current density and electric field both point left
C) the current density points right and the electric field points left
D) the current density points left and the electric field points right

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Brief explanation: The drift velocity is always along the direction of the motion of charge carriers. v_d

negative charge carriers J and v_d have opposite directions. However, J and E are always in the same direction. Therefore, the correct answer is **choice B is correct**.

2A cylindrical copper rod has resistance R. It is reformed to twice its original length with no change of volume. Its new resistance is

A) R B) 2R C) 4R D) R/2

initially resistance=R, $\ell_f = 2\ell_0$ and $V_f = V_o$

$R_{new} = ?$ Since the volume is not changed, $A_0\ell_0 = A\ell$

$\Rightarrow A_0\ell_0 = A(2\ell_0) \Rightarrow A = \frac{A_0}{2}$ The initial resistance is $R = \rho\frac{\ell}{A}$ and

$$R_{new} = \rho\frac{(2\ell_o)}{\frac{A_0}{2}} \Rightarrow \underline{\underline{R_{new} = 4R}}$$

The new resistance is .

3. A copper wire of length $1m$ and radius $1mm$ is joined in series with an iron wire of length $2m$ and radius $3mm$ and a current is passed through the wire. The ratio of current densities in the copper and iron wire is A) 18:1 B) 9:1 C) 6:1 D) 2:3

Brief explanation and solution:

$J = \frac{I}{A}$ when the current is constant, then $J \propto \frac{1}{A}$

$$\frac{J_{copper}}{J_{iron}} = \frac{A_{iron}}{A_{copper}} = \left(\frac{r_{iron}}{r_{copper}}\right)^2 = \left(\frac{3}{1}\right)^2 = \frac{9}{1}.$$

4. The emf of a battery is equal to its terminal potential difference:

A) under all conditions B) only when the battery is being charged

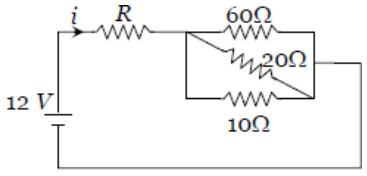
C) only when a large current is in the battery

D) only when there is no current in the battery

Brief explanation: $V_{ab} = \varepsilon - Ir$. Hence, the $V_{ab} = \varepsilon$ only when there is no current in the battery.

5. If in the given figure I = 0.25 A, then the value R will be

A) 48 Ω
B) 12 Ω
C) 120 Ω
D) 42 Ω



$R_{eq} = \frac{V}{i} = \frac{12V}{0.25A} = 48\Omega$ and

$\frac{1}{R'} = \frac{1}{60\Omega} + \frac{1}{20\Omega} + \frac{1}{10\Omega}$

$\Rightarrow R' = 6\Omega$ thus $R_{eq} = R + R' \Rightarrow 48\Omega = R + 6\Omega \Rightarrow \underline{\underline{R = 42\Omega}}$.

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6. For a cell, the terminal potential difference is 2.2 V when the circuit is open and reduces to 1.8 V, when the cell is connected across a resistance, $R = 5\Omega$. The internal resistance of the cell is

A) $\frac{10}{9}\Omega$ B) $\frac{9}{10}\Omega$ C) $\frac{11}{9}\Omega$ D) $\frac{5}{9}\Omega$

Brief explanation: In open circuit, $\varepsilon = V = 2.2\ V$, In close circuit, $V = 1.8\ V$, $R = 5\Omega$. When the circuit is closed the terminal potential difference is

$$\Rightarrow V = IR \Rightarrow I = \frac{V}{R} \Rightarrow I = \frac{1.8V}{5\Omega} = 0.36A$$

And $V = \varepsilon - Ir \Rightarrow r = \frac{\varepsilon - V}{I} = \frac{0.4}{0.36}$ $r = \frac{4}{3.6} = \frac{10}{9}\Omega$.

7. When the resistance of 2 Ω is connected across the terminal of the cell, the current is 0.5 *amp*. When the resistance is increased to 5Ω, the current is 0.25 amps. The emf of the cell is

A) 1.0 volt B) 1.5 volt C) 2.0 volt D)2.5 volt

Solution: $R_1 = 2\Omega, I_1 = 0.5A$ *and when* $R_2 = 5\Omega,\ I_2 = 0.25\ A$

$V_{ab_1} = \varepsilon - I_1 r$ *and* $V_{ab_2} = \varepsilon - I_2 r$ $I_1R_1 = \varepsilon - (0.5)r$ *and* $I_2R_2 = \varepsilon - (0.25)r$

$\begin{cases} 1 = \varepsilon - (0.5)r \\ 1.25 = \varepsilon - (0.25)r \end{cases}$ Solving these equations simultaneously gives ε=1.5 V.

8. A certain resistor dissipates 0.5 W when connected to a 3V potential difference. When connected to a 1 V potential difference, this resistor will dissipate:

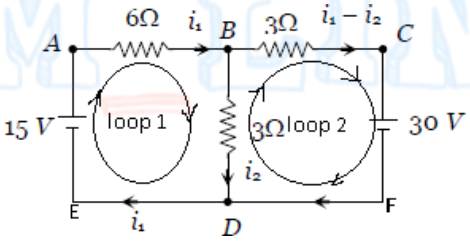
A) 0.5 W B) 0.167 W C) 1.5 W D) 0.056 W

Solution: $P_1 = 0.5W, V_1 = 3V, V_2 = ?\quad P_2 = ?$

$P_1 = \frac{V_1^2}{R}$ and $P_2 = \frac{V_2^2}{R}$

$$\frac{P_1}{P_2} = \left(\frac{V_1}{V_2}\right)^2 \Rightarrow P_2 = \left(\frac{V_2}{V_1}\right)^2 P_1 \Rightarrow P_2 = \frac{0.5}{9} = 0.056W$$

9. In the circuit shown in figure, find the current through the branch BD A) 5 A B) 0 A C) 3 A D) 4 A



Solution: we are going to apply the junction and loop rule.

- at junction B or junction D $i_1 = i_2 + i_3 \Rightarrow i_3 = i_1 - i_2$
- From **loop 1**

  $-6i_1 - 3i_2 + 15 = 0 \Rightarrow 2i_1 + i_2 = 5 - - - - - - *$
- **From loop 2**

  $-3(i_1 - i_2) - 30 + 3i_2 = 0 \Rightarrow -i_1 + 2i_2 = 10 - - - - - - **$. **Solving * and ** simultaneously**

  $i_2 = 5A$ The correct **answer is B**

10. To make a galvanometer into an ammeter, connect:

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A) a high resistance in parallel B) a high resistance in series
C) a low resistance in series D) a low resistance in parallel

Brief explanation: To make a galvanometer into an ammeter, connect a small resistance called shunt resistance in parallel with the galvanometer. Choice C is correct.

11. A certain voltmeter has an internal resistance of 10, 000 Ω and a range from 0 to 12 V. To extend its range to 120 V, use a series resistance of:

A) 1, 111 Ω B) 90, 000 Ω C) 100, 000 Ω D) 108, 000 Ω

Solution: $G = R_g = 10{,}000\Omega,\ V_g = full\ scale = 12V$ R=?

$$I_g = \frac{12}{10{,}000} A = \frac{V_g}{R_g},\ V = 120V$$

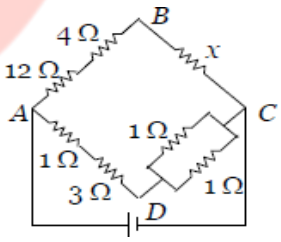
$$\Rightarrow V = I_g\left(R + R_g\right) \Rightarrow 120 = \frac{12}{10{,}000}\left(R + 10{,}00\right)$$

$$\Rightarrow R = 100{,}000 - 10{,}00$$

$$\Rightarrow \underline{\underline{R = 90{,}00\Omega}}$$

12. In the combination of resistances shown in the figure the potential difference between *B* and *D* is zero, when unknown resistance (*x*) is_____

A) 4 Ω B) 2 Ω C) 3 Ω D) The emf of the cell is required



Solution: The potential difference across *B*, *D* will be zero, when the circuit will act as a balanced Wheatstone bridge Therefore, from balanced bridge circuit $\frac{P}{Q} = \frac{R}{S} \Rightarrow \frac{12+4}{x} = \frac{1+3}{1/2} \Rightarrow \underline{\underline{x = 2\Omega}}$. **Ans** B

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Unit 12: Review and Summary on Magnetism

12.1 Concepts of magnetic field and magnet

- **Magnetic fields** in space are represented by **Magnetic field lines** and the strength of the magnetic field is proportional to the density of magnetic field lines.
- **Magnetic flux** Φ is the number of magnetic field lines crossing a surface perpendicularly. It is given by $\Phi = BA\sin\theta$,

  Where, B is the magnetic field strength, A is the area of the surface, θ is the angle between the surface and the magnetic field.

Motion of charged particles in a Magnetic Field

- When a charge q moves at a velocity $\vec{v}$ in a magnetic field of strength $\vec{B}$ it experiences amagnetic force given by given by

$$\vec{F} = q(\vec{v} \times \vec{B})$$

- A charge moving with a velocity **v** in the presence of both an **electric field E** and **a magnetic field B** experiences both an electric force and magnetic force. $\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$
- When the magnitudes of the two fields are chosen so that $qE = qvB\sin\theta$, the particle moves in a straight horizontal line through the region of the fields. And the velocity of the charge is

$$\Rightarrow v = \frac{E}{B}\sin\theta$$

Thompson's Experiment of Charge to mass ratio

- The velocity of the electrons in the accelerator is given by

$$v = \sqrt{\frac{2qV}{m}}$$

- The charge to mass ratio is $\frac{q}{m} = \frac{E^2}{2VB^2}$

Circular motion of charged particles in a Magnetic Field

- The **magnetic force** on a charge moving in a magnetic field is **always perpendicular** to its velocity because it is in the direction of cross product of its velocity and the magnetic field. Hence the force is like a centripital force. $qvB = \frac{mv^2}{r}$
- The radius of the circle of the path of the charge is $r = \frac{mv}{qB}$
- The period of the charge is $T = \frac{2\pi r}{v}$, from the above expression $\frac{r}{v} = \frac{m}{qB}$, hence $T = \frac{2\pi m}{qB}$ and its frequency is $f = \frac{1}{T} = \frac{qB}{2\pi m}$, the angular frequency is $\omega = 2\pi f = \frac{qB}{m}$ $\frac{q}{m} = \frac{2V}{r^2B^2} \Rightarrow m = \frac{qr^2B^2}{2V}$

The mass spectrometer

- The mass of different chemicals can be identified by using different accelerating potential V.

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Magnetic force on a current carrying conductors

- The magnetic force on a current carrying conductor placed in a magnetic field is given by $\vec{F} = l(\vec{I} \times \vec{B})$,

  Where l is the length of the conductor and I is the current in the conductor. Its magnitude is $\vec{F} = l(\vec{I} \times \vec{B}) = I\,lB\sin\theta$, where θ the angle between the magnetic fields B and the wire

The magnitude and direction of torque acting on a current loop

- The **torque** on a current carrying loop of area A in a magnetic field **B** is given by $\tau = I(\vec{A} \times \vec{B}) = IAB\sin\theta$, where θ is the angle between the magnetic field and the normal to the plane of the loop.
- The product IA is defined to be the magnetic dipole moment μ (often simply called the "magnetic moment") of the loop:
- If the loop is composed of N turns the magnetic moment is NIA. The **torque** can be expressed as $\tau = \vec{\mu} \times \vec{B} = \mu B\sin\theta$

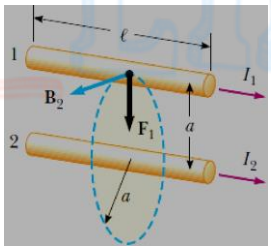
The magnetic field produced by a current carrying straight conductor.

- A **current carrying straight conductor** produces a magnetic field in a **circular loop.**
- The **strength of the field** at a distance r from the conductor is given by $B = \frac{\mu_0 I}{2\pi r}$, where I is the current in the conductor, and μ_0 is permittivity of free space

Magnetic force between two parallel current carrying wires

- If two long, straight, parallel wires separated by a distance r and carrying currents I_1 and I_2 they will experience a force given by

$$F = \frac{\mu_0 I_1 I_2}{2\pi r} l$$



- Generally, the force is **attractive** if the currents are in the **same direction** and the force is **repulsive** if the currents are in **opposite directions**.

Biot Savart Law and determining the expression for Magnetic field Strength of a current element

- The Biot–Savart law says that the magnetic field dB at a point P due to a length element dl that carries a steady current I is

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Idl \times \hat{r}}{r^2}$$

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Ampere's Law and its Applications

- Ampere's Law states that the summation of the product of the tangential component of the magnetic field ($B_{\parallel}$) at a certain point and a small path element (Δl) evaluated over a closed path is equal to the product of the permeability of free space and the total current in the loop. $\sum B_{\parallel}\ \Delta l = \mu_0 I$
- Magnetic field **inside a wire** the circumference of the circle of radius r. $B_r = \frac{\mu_0}{2\pi r}\frac{r^2}{R^2} I = \frac{\mu_0 I}{2\pi}\frac{r}{R^2}$
- Magnetic field of s a Solenoid is uniform inside the solenoid and is given by $B = \mu_0 nI$.
- Magnetic field of s a **Toroid** is $B = \frac{\mu_0 NI}{2\pi r}$

Earth's Magnetic Field

- The earth's magnetic field has both **vertical** and **horizontal** components except at the poles of the earth. At the **poles** they are perpendicular to the surface of the earth.
- The earth magnetic moment can be measured using a tangent Galvanometer.
- When a current is applied in it magnetic field will be produced at the center of the coils of it and given by $B_C = \frac{\mu_0 NI}{2R}$, where R is the radius of the coil. N is the number of turns, I is the current in the coil.
- When the plane of the coil is placed along the Magnetic meridian B_c the horizontal component of the earth's magnetic field will be perpendicular.
- The horizontal component of the earth's magnetic field is $B_e = \frac{B_C}{\tan\theta}$,

12.2 Topics Related Questions on Unit 13

I- Choose the correct answer for the following Questions.

14. Consider a circular loop of radius 0.04m placed on the x-y plane. Find the flux on it if there is a magnetic field of 5T directed to the z axis.

Solution: Since x-y plane and z axis are perpendicular, the magnetic field is perpendicular to the surface of the loop, hence $\theta = 90^0$.

$$\Phi = BA\sin\theta = B\pi r^2 \sin(90^0) = 5T \times 3.14(0.04m)^2 \times 1 = 2.51\times10^{-2}\,Tm^2 = 2.51\times10^{-2}\ \text{weber}$$

A $4mC$ charge is going north-east with a speed of 600m/s in a uniform magnetic field of strength 2T directed towards east. Determine the magnitude and direction of the magnetic force on the charge.

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Solution: North-east means at an angle of 45^0 from the east direction to the north direction hence $\theta = 45^0$. The magnitude of the force is

$$F = |q|vB\sin\theta = 4\times10^{-3}C\times600m/s\times2T\times\sin45^0$$
$$= 2.4Cm/s\times2T\times0.707 = 3.4N$$

An electron moving along the +x-axis enters a magnetic field. If the electron experiences a magnetic deflection in the -y direction, what is the direction of the magnetic field in this region?

A) along the +y-axis B) along the -z-axis
C) along the -x-axis D) along the +z-axis

Brief explanation: Taking directions only in the equation below and inserting $-\hat{j}$ in place of $\vec{F}$, $\hat{i}$ in place of $\vec{v}$ and q is negative.

$\vec{F} = q(\vec{v}\times\vec{B})$ $\Rightarrow -\hat{j} = -(\hat{i}\times\hat{B})$ $\Rightarrow \hat{j} = (\hat{i}\times\hat{B})$, we know that $(\hat{i}\times-\hat{k}) = \hat{j}$ hence $\vec{B}$ is in the direction of –z direction

Calculate the charge to mass ratio for charged particles in a J. J. Thomson tube with accelerating voltage of 3000V and crossed fields of E = 6.5 ×10⁴ V/m and B = 2.0×10-3T.

A) $1.76\times10^{11}C/Kg$ B) $3.4\times10^{11}C/Kg$ C) $2.4\times10^{11}C/Kg$ D) $4.8\times10^{11}C/Kg$

Solution:

$$\frac{q}{m} = \frac{E^2}{2VB^2} = \frac{(6.5\times10^4\,V/m)^2}{2(3000V)(2.0\times10^{-3}T)} = 1.76\times10^{11}C/Kg$$

Two ions of different masses enter at equal speed perpendicularly to a magnetic field in a mass spectrometer. If the charge of the first is four times to the second and radius of path of the first is two times the radius of the second one. Find their mass ratio $\frac{m_1}{m_2}$.

A) 16 B) 8 C) 4 D) 2

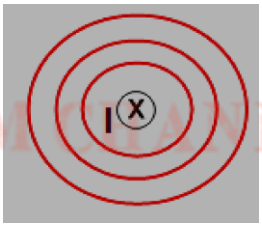
Solution: From $m = \frac{qr^2B^2}{2V}$, $\frac{m_1}{m_2} = \frac{q_1r_1^2}{q_2r_2^2} = \frac{4q_2(2r_2)^2}{q_2r_2^2} = 16$,

A current of 5 A passes along a wire of length 1.0 m. The wire is at right angles to a magnetic field of 0.15 T. The magnitude of the force acting on the wire is? A)

4N B) 3N C) 1.5N D) 0.75N

Solution: $F = IlB\sin\theta = 5A\times1m\times0.15T\sin90^0 = 0.75N$

An electric current flows into the page as shown in the figure below. What is the direction of the magnetic field?



A) To the bottom of the page B) To the top of the page.
C) Clockwise. D) Counter-clockwise.

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Brief explanation: By using the right hand rule and pointing the right thumbs in to the page the forefingers curl in to clockwise hence the field will be in clockwise direction.

Two parallel wires of length 2m each are separated by 0.5m. The two wires carry current of 5A and 8A in opposite directions. Find the force on each wire.

A) $3.2\times10^{-5}N$ attractive B) $3.2\times10^{-5}N$ repulsive

C) $1.6\times10^{-5}N$ attractive D) $1.6\times10^{-5}N$ repulsive

Solution: $F=\frac{\mu_0 I_1 I_2}{2\pi r}l=\frac{4\pi\times10^{-7}Tm/A\times5A\times8A}{2\pi\times0.5m}\times2m=3.2\times10^{-5}N$,

Since the currents are in opposite direction the force is repulsive

Calculate the magnetic field inside a solenoid of 300 turns per centimeter carrying a current of 0.05A.

A) $5.6\times10^{-3}T$ B) $3.8\times10^{-3}T$ C) $2.4\times10^{-3}T$ D) $1.9\times10^{-3}T$

Solution: The number of turns per unit length

$n=\frac{300}{0.01m}=30000\,\text{turns}/m$, hence

$B=\mu_0 nI=4\times10^{-7}\,\text{Tm/A}(30000\text{turns/m})(0.05\text{A})=1.9\times10^{-3}T$

A circular coil of 5 turns and a diameter of 30 cm is oriented in a vertical plane with its axis perpendicular to the horizontal component of the Earth's magnetic field. A horizontal compass placed at the center of the coil is made to deflect 45.0° from magnetic north by a current of 0.6 A in the coil. What is the horizontal component of the Earth's magnetic field?

A. $12.6\times10^{-6}T$ B. $6.3\times10^{-6}T$ C. $4.4\times10^{-6}T$ D. $2.1\times10^{-6}T$

Solution:

$$B_e=\frac{B_C}{\tan\theta}=\frac{\mu_0 NI}{2R}/\tan\theta=\frac{4\pi\times10^{-7}T.m/A\times5\times0.6ANI}{2\times0.3m}/\tan45^0$$
$$=20\pi\times10^{-7}T=6.3\times10^{-6}T$$

A wire carries a steady current of 2.4 A. A straight section of the wire is 0.75 m long and lies along the x-axis within a uniform magnetic field B=1.6 T along the +z axis. If the current is in the +x direction, what is the magnetic force on the section of the wire?

A. 2.88 j N B. 1.62 j N C. -1.62 j N D. - 2.88 j N

Solution: The force on a current carrying wire of length l in a magnetic field **B** is given by

$\vec{F}=l(\vec{I}\times\vec{B})=\vec{F}=0.75m(2.4A\hat{i}\times1.6T\hat{k})=2.88N(\hat{i}\times\hat{k})$

$=2.88N(-\hat{j})$

If a wire carrying current in the plane of this paper towards the top of the page experiences a magnetic force towards the right edge of the page, what will be the direction of the magnetic field causing this force?

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A) In the plane of the page and towards the left edge.

B) In the plane of the page and towards the bottom edge.

C) Perpendicular and directed out of the plane of the page.

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D) Perpendicular and directed in to the plane of the page.

Solution: The current is out ward (in + z) direction. And the force is in +x direction. Taking only directions and using $\hat{i} = \hat{k} \times \hat{B}$, from vector product we know that $\hat{k} \times (-\hat{j}) = \hat{i}$, hence $\hat{B} = -\hat{j}$, the field is down ward (bottom of the edge)

Two parallel copper wires are 1m apart. Lightening sends a 10,000A pulse of current along each conductor. What is the force per unit length on one conductor? A. 1000N/m B. 200N/m C. 20N/m D. 2000N/m

Solution: The force on them is given by $F = \frac{\mu_0 I_1 I_2}{2\pi r} l$, and then the force per unit length is

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r} = \frac{4\pi \times 10^{-7} Tm/A \times 10^4 A \times 10^4 A}{2\pi \times 0.01m} = 2000 N/m$$

Unit 13: Review and Summary on Electromagnetic Induction and A. C circuit

13.1 Short notes on Electromagnetic Induction

- The **magnetic flux** ϕ_B through a closed loop is defined as $\phi_B = BA\cos\theta$

- **Faraday's law of induction** states that the instantaneous emf induced in a circuit equals the negative of the rate of change of magnetic flux through the circuit

$$\varepsilon = -N\frac{d\phi_B}{dt}$$

- **Lenz's law** states that the current from the induced emf creates a magnetic field with flux opposing the *change* in magnetic flux through a circuit.

- If a conducting bar of length ℓ, moves through a magnetic field with a speed v so that $\vec{B}$ is perpendicular to the bar, the emf induced in the bar, often called a **motional emf**, is $\varepsilon = -B\ell v$

- The **inductance** of a coil can be found from the expression $L = \frac{N\phi_B}{I}$ If an AC circuit consists of a generator and a **capacitor**, the **voltage lags** behind the current by 90°.

AC circuits

- If an AC circuit consists of a generator and an inductor, the voltage leads the current by 90°.

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✧ If an AC circuit contains a resistor, an inductor, and a capacitor connected in series, the limit they place on the current is given by the **impedance** Z of the circuit, defined as $Z = \sqrt{R^2 + (X_L - X_C)^2}$

✧ The current amplitude I in a series RLC circuit driven by a sinusoidal external emf is a maximum when the driving angular frequency *equals* the natural angular frequency of the circuit (that is, at *resonance*). Then $X_C = X_L$, $\varphi=0$, and the current is in phase with the emf.

13.2 Topic Related questions Unit 14

I- Choose the correct answers for the following Questions

1. A 10-turn ideal solenoid has an inductance of 4.0mH. To generate an emf of 2.0V the current should change at a rate of:
   A) 5.0A/s B) 50A/s C) 250A/s D) 500A/s

Solution: $\varepsilon = 2V, L = 4x10^{-3} H, N = 10 \qquad \frac{\Delta I}{\Delta t} = ?$

$$|\varepsilon| = NL\frac{\Delta I}{\Delta t} \Rightarrow \frac{\Delta I}{\Delta t} = \frac{|\varepsilon|}{NL} = \frac{2V}{(10)(4x10^{-3})} = \underline{\underline{500 A/s}}$$

2. A piece of electrical equipment in an ac circuit draws a root-mean-square current of 5 A. The average current over each cycle is

   A) $5\sqrt{2}$ A B)5 A C) $\frac{5}{\sqrt{2}}A$ D) 0

   Brief explanation: In an ac circuit, there are as many positives as there are negatives in both the sinusoidal current and voltage. Therefore, the **average current** and average voltages are **zero**.

3. For the current to have its maximum value in a series R–L–C ac circuit,

   A) $\omega = 0$ B) $\omega \to \infty$ C) $\omega = \frac{1}{\sqrt{LC}}$ D) $\omega = 1$

   Brief explanation: The current is maximum when the circuit is in **resonance** and then occurs when the resonant angular frequency is $\omega = \frac{1}{\sqrt{LC}}$.

4. If the root-mean-square current in an ac circuit is 10.0 A, the current amplitude is approximately A) 7.07A B)5.00A C) 14.1A D) 20.0 A

Solution: $I_{rms} = 10A \quad I_0 = ?$

$$I_{rms} = \frac{I_0}{\sqrt{2}} \Rightarrow I_0 = (I_{rms})\sqrt{2} \Rightarrow \underline{\underline{I_0 = 14.1A}}$$

5. In a series R–L–C ac circuit at resonance,

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A) The impedance is zero. B) The impedance has its maximum value.

C) The reactance is equal to *R*.

D) The total impedance has its minimum value, which is equal to *R*.

Brief explanation: Remember the key points of resonance

- $\overline{P}$ is maximum
- I_0 is maximum
- Z is minimum
- Z = R which implies that $\cos\phi = 0$. Choice D is correct.

6. At what frequency is the reactance of a 1.0μF capacitor equal to 500Ω? A) 320 Hz B) 500 Hz C) 640 Hz D) 2000 Hz

Solution: $C = 1\mu F,\ X_C = 500\Omega \quad f = ? \quad X_C = \frac{1}{\omega C} \Rightarrow \omega = \frac{1}{X_C C} \Rightarrow \omega = \frac{1x10^6}{500\Omega} \Rightarrow \omega = 2000 rad/s$

7. In an *R–L–C* series circuit, the rms voltage across the resistor is 30.0 V, across the capacitor it is 90.0 V, and across the inductor it is 50.0 V. What is the rms voltage of the source?

A) 25 V B) 50 V C) 100 V D) 40 V

Solution: $V_{rms\,R} = 30V,\ V_{rms\,C} = 90,\ V_{rms\,L} = 50V \qquad V_{rms\,S} = ?$

$V_{rmsR} = I_{rms}R \Rightarrow R = \frac{30}{I_{rms}}$, $V_{rms\,C} = I_{rms}X_C \Rightarrow X_C = \frac{90}{I_{rms}}$ $V_{rms\,L} = I_{rms}X_L \Rightarrow X_L = \frac{50}{I_{rms}}$.

However, rms voltage of the source is given by $V_{rms\,S} = \mathrm{I_{rms}} Z \ and\ Z = \sqrt{R^2 + (X_L - X_C)^2}$

$\Rightarrow Z = \sqrt{\left(\frac{30}{I_{rms}}\right)^2 + \left(\frac{50}{I_{rms}} - \frac{90}{I_{rms}}\right)^2} \Rightarrow Z = \frac{1}{I_{rms}}\sqrt{900 + 1600}$

$\Rightarrow Z = \frac{50}{I_{rms}}$. Therefore, the source r-m-s voltage is $V_{rms\,S} = I_{rms}Z \Rightarrow V_{rms\,S} = I_{rms}\frac{50}{I_{rms}} \Rightarrow \underline{\underline{V_{rms\,S} = 50V}}$

$\Rightarrow 2000 = 2\pi f \Rightarrow f = \frac{2000}{6.28} \Rightarrow \underline{\underline{f \approx 320Hz}}$.

8. An RLC circuit has a sinusoidal source of emf. The average rate at which the source supplies energy is 5nW. This must also be:

A) the average rate at which energy is stored in the capacitor

B) the average rate at which energy is stored in the inductor

C) the average rate at which energy is dissipated in the resistor

D) twice the average rate at which energy is stored in the capacitor

Brief explanation: The average power dissipated in reactive elements is zero. Therefore, the answer

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is C.

9. In a purely capacitive circuit, the current:
   A) leads the voltage by one-fourth of a cycle B) leads the voltage by one-half of a cycle
   C) lags the voltage by one-fourth of a cycle D) lags the voltage by one-half of a cycle
   Brief explanation: It's highly advisable to remember this **mnemonic** to remember who leads and who lags in AC circuits
   "***ELI* the *ICE* man**." ***ELI*** contains the letter *L* (for inductor), and in it the letter *I* (for current) comes *after* the letter *E* (for emf or voltage). Thus, for an **inductor, the current *lags*** (comes after) the voltage. Similarly ***ICE*** (which contains a *C* for **capacitor**) means that the **current *leads*** (comes before) the voltage. Therefore, **Answer is A**
10. A coil has a resistance of 60 Ω and an impedance of 100 Ω. Its reactance, in ohms, is: A) 40 B) 60 C) 80 D) 160

    Solution: $R = 60\Omega,\ Z = 100\Omega$ **Required** $X = ?$

    $Z^2 = R^2 + X^2 \Rightarrow 10000 = 3600 + X^2 \Rightarrow \underline{\underline{X = 80\Omega}}$ **Ans :(C).**
11. The primary of an ideal transformer has 100 turns and the secondary has 600 turns. Then:
    A) the power in the primary circuit is less than that in the secondary circuit
    B) the currents in the two circuits are the same
    C) the voltages in the two circuits are the same
    D) the primary current is six times the secondary current

    Solution: $\frac{N_P}{N_S} = \frac{I_S}{I_P} \Rightarrow \frac{I_S}{I_P} = \frac{1}{6} \Rightarrow \underline{\underline{I_P = 6I_S}}$ **Ans :(D)**
12. A **solenoid** with rectangular cross-section has **N** = 3250 turns, length [illegible] = 52.0 cm and area **A** = 110 cm². If it is carrying a current **I** = 53.0A, what is the **energy density** inside?

    Solution: $N = 3250, \text{[illegible]} = 0.52m, A = 110cm^2, I = 53A$ $u = ?$

    the energy density with in a solenoid is given as $u = \frac{1}{2}\frac{B^2}{\mu_0} \Rightarrow u = \frac{\mu_0 I^2 N^2}{2\text{[illegible]}}$

    $u = \frac{\mu_0}{2}\left(\frac{IN}{\text{[illegible]}}\right)^2 \Rightarrow u = 6.91x10^4\, J/m^3$
13. If the magnetic flux through a certain region is changing with time:
    A) energy must be dissipated as heat B) an electric field must exist at the boundary
    C) a current must flow around the boundary D) an emf must exist around the boundary
    Brief explanation: According to the faraday's law, as the magnetic flux through a certain region is changing with time an emf must exist around the boundary. **Ans :(D)**.
14. The emf developed in a coil X due to the current in a neighboring coil Y is proportional to the:
    A. magnetic field in X B. rate of change of magnetic field in X
    C. resistance of X D. thickness of the wire in X
    Brief explanation: The induced emf in a certain coil is proportional to the rate at which the flux through itself varies with time. **Answer B**.
15. What is the emf induced when a 18 cm conducting rod attached to a u shaped conductor moves at a speed of 1 cm/s perpendicular to magnetic field of strength 37.5 T?

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A) 3 V B) 2.1 V C) 0.07 V D) 0.03 V

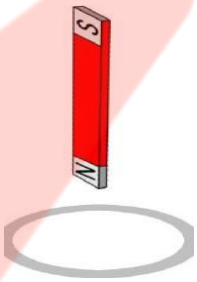
Solution: $\ell = 18cm, v = 1cm/s = 0.01m/s, B = 37.5T \qquad \varepsilon = ?$

The motional emf induced when the conductor's velocity, length and the magnetic field are all perpendicular is given by the equation

$$\varepsilon = B\ell v \Rightarrow \varepsilon = (37.5T)(0.18m)(0.01m/s)$$

$$\varepsilon = 0.0675 \Rightarrow \underline{\varepsilon \approx 0.07V}$$. **Answer D**

16. A bar magnet with the North Pole facing down is dropped above a conducting ring. As the magnet passes through the ring, what is the direction of the induced current in the ring?



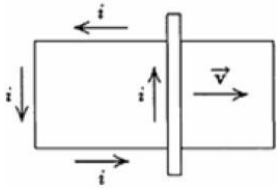
A) always clockwise B) always counter clockwise
C) first clockwise then counter clockwise
D) first counter clockwise then clockwise

Brief explanation: While the magnet is falling the direction of the field crossing the ring is downward and increasing. Therefore, $B_{induced}$ must be upward.

And when it moves past the circular ring the external field is down and decreasing.

Here again the $B_{induced}$ must be down ward. Therefore, since in both cases the induced field is upward in the first case and down in the second case the corresponding current must be directed first counterclockwise and then clockwise. **Answer D**

17. The figure shows a bar moving to the right on two conducting rails. To make an induced current i in the direction indicated, in what direction would the magnetic field be in the area contained within the conducting rails?



A) out of the page B) to the left
C) into the page D) to the right

Solution: Using Lenz law, as the loop expands with the motion of the bar; it is gaining flux lines in whatever direction the B field is and the loop current flows in a direction to oppose that gain.

Using RHR–solenoid for the single loop, for $I_{induced}$ to be directed as shown the $B_{induced}$ must be out of the page. Therefore, the external field within the area must **be into the page** and increasing.

Answer C

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