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MEXHANICAL ENGINEERING

19/ENG06/012

PHY 102

SECTION A

 1a.ChargingbyInduction:

Electric charges can be obtained ,by a process calledelectrostaticinduction.

Considerapositivelychargedrubberrodbroughtnearaneutral(uncharged)conductingsphere thatisinsulatedsothatthereisnoconductingpathtogroundasshownbelow.Therepulsiveforce betweentheprotonsintherodandthoseinthespherecausesaredistributionofchargesonthe spheresothatsomeprotonsmovetothesideofthespherefarthestawayfromtherod.The regionofthespherenearestthepositivelychargedrodhasanexcessofnegativechargebecause ofthemigrationofprotonsawayfromthislocation.Ifagroundedconductingwireisthen connectedtothesphere,asin(fig.1.3b),someoftheprotonsleavethesphereandtraveltothe earth.Ifthewiretogroundisthenremoved,theconductingsphereisleftwithanexcessof inducednegativecharge.

Finally,whentherubberrodisremovedfromthevicinityofthesphere,the inducednegativelychargeremainsontheungroundedsphereandbecomes uniformlydistributedoverthesurfaceofthesphere.

Diagram:







3a.

dQ→dQ=ρdV (i) Volumechargedensity,ρ= dV

dQ→dQ=σdA

(ii) Surfacechargedensity,σ= dA

dQ→dQ=λdL

(iii)Linearchargedensity,λ=

dL

# 3b.ELECTRICPOTENTIALDIFFERENCE

Theelectricpotentialdifferencebetweentwopointsinanelectricfieldcanbe definedastheworkdoneperunitchargeagainstelectricalforceswhenachargeis transportedfromonepointtotheother.ItismeasuredinVolt(v)orJoulesper Coulomb(J/C).Electricpotentialdifferenceisascalarquantity.



Considerthediagramabove,supposeatestchargeqoismovedfrompointAto pointBalonganarbitrarypathinsideanelectricfieldE.TheelectricfieldE exertsaforceF=qoEonthechargeasshowninfig3.1.Tomovethetestcharge fromAtoBatconstantvelocity,anexternalforceofF=-qoEmustactonthe charge.Therefore,theelementalworkdonedWisgivenas:

|  |  |
| --- | --- |
| dW=F.dL…But | (1) |
| F=-q0E… | (2) |

Substitutingequation(2)in(1)yields

dW=-q0EdL… (3)

ThentotalworkdoneinmovingthetestchargefromAtoBis:

W(A→B)Ag=-q0∫BEdL… (4)

A

Fromthedefinitionofelectricpotentialdifference,itfollowsthat:

W(A→B)Ag

VB-VA= q0 … (5)Puttingequation(4)in(5)yields

B

VB-VA=-EdL… (6)

∫

A

SECTIONB.

4a.magneticfluxisdefinedasthestrengthofthemagneticfield whichcanberepresentedbylineofforces.Itisrepresentedby thesymbolΦ.mathematicallygivenasΦ=B.dA 4b.



4c.Inthequestionweweregivenparamiterssuchas i.massoftheelectron=9.11x10-31kg ii.Aradiusof1.4x10-7m iii.magneticfieldof3.5x10-1weber\metersquare andyouareaskedtofindthecyclotronfrequencywhichisequalor thesamethingasangularspeed.itiscalledcyclotronfrequency becauseitisafrequencyofanacceleratorcalledcyclotron.

Recallthatangularspeedisgivenasω=v=qB

rm

Substitutingwehaveω=v=qB=1.6x10-10x3.5x10-10

rm

9.11x10-31

qB=1.6×10-19x3.5x10 -1=6.15×1010rad/s m 9.11x10 -31

SOsincecyclotronfrequencyisequaltoangularspeedthe cyclotronfrequencyisequalto6.15×1010rad/s

,havingaunitas1\Twhichisequaltotheunitoffrequency dimensionally.

5a.Biot-savartlawstatesthatthemagneticfieldisdirectly proportionaltotheproductpermeabilityoffreespace(µ),the current(I),thechangeinlength,theradiusandinversely proportionaltosquareofradius(r2).Itcanberepresented mathematicallyby

μoIdl×̂r

dB=4π r2

whereμoisaconstantcalledPermeabilityoffreespace.

μo=4π×10-7T~~.~~m

A

TheunitofBisweber\metresquare

5b.MagneticFieldofaStraightCurrentCarryingConductor

Fig1:AsectionofaStraightCurrent

CarryingConductor

ApplyingtheBiot-Savartlaw,wefindthe magnitudeofthefielddB

B

sin(π–φ)=sinθ

∴B=μ4oπI∫a-adlsin(rπ2-φ)

Fromdiagram,r2=x2+y2(Pythagorastheorem)

μoIadlsin(π–φ)

B=4π∫-ax2+y2… (\*)

Butsin(π-φ)=x2x+y2=(x2+xy2)12… (\*\*)

Substituting(\*\*)into(\*),wehave

B=μ4oπI∫a-adl(x2+y2)(xx2+y2)1/2

 μoIa x

B=4π∫-adl(x2+y2)3/2 Recalldl=dy

 B o 2dy

=

I

μ

4

π

∫

a

-

a

x

(

+

x

2

y

2

)

3

 B 23/2dy… (\*\*\*)

Usingspecialintegrals:

dy 1 y

=

~~∫~~(x2+y2)3/2 x2(x2+y2)1/2

Equation(\*\*\*)thereforebecomes

μoIx y a

B=4π[x2(x2+y2)12]-a

B=μ4oπIx(x2(x22+aa2)12)

B=4μπoIx((x2+2aa2)12)

Whenthelength2aoftheconductorisverygreatincomparisontoitsdistancex frompointP,weconsideritinfinitelylong.Thatis,whenaismuchlargerthan,x (x2+a2)1/2≅a,asa→

∴

B

=

I

μ

o

2

π

x

Inaphysicalsituation,wehaveaxialsymmetryaboutthey-axis.Thus,atallpoints inacircleofradius,aroundtheconductor,themagnitudeofBisr

B=μoI… (#)

2πr

Equation(#)definesthemagnitudeofthemagneticfieldoffluxdensityBneara long,straightcurrentcarryingconductor.