**ori dguSi (5 qula)**

horizontalurad moTavsebuli cilindris kedlebi Tbogaumtaria. is gayofilia sam A1, A2 da A3 nawilad S1 da S2 dguSebiT, romlebsac xaxunis gareSe SeuZliaT moZraoba. S1 dguSi Tbogaumtaria, xolo S2 \_ kargi Tbogamtaria (ix. nax.). Tavidan samive nawili Seicavs TiTo mol heliums. TiToeuli maTganis wnevaa P0, moculobaa V0, xolo temperaturaa T0. helimi ganvixiloT rogorc idealuri erTatomiani airi. mudmivi moculobisas misi moluri siTbotevadobaa Cv=3R/2, xolo mudmivi wnevisas \_ Cp=5R/2. airs A1 nawilSi nela miawodes siTbo manam, sanam A3 nawilSi airis temperatura gaxda T3=9T0/4.

a) A1, A2 da A3 nawilebSi saboloo mdgomareoba iyos Sesabamisad (P1,V1,T1), (P2,V2,T2) da (P3,V3,T3). SeavseT qvemoT moyvanili cxrili. wnevebi gamosaxeT P0–iT, moculobebi \_ V0–iT, xolo temperaturebi \_ T0–iT.

|  |  |  |
| --- | --- | --- |
| P1= | P2= | P3= |
| V1= | V2= | V3= |
| T1= | T2= | T3= |

b) gansazRvreT A1 nawilSi moTavsebuli airis mier Sesrulebuli muSaoba.

g) gansazRvreT ra siTbos raodenoba miiRo saxureblidan A1 nawilSi moTavsebulma airma.

**amoxsna:**

a) T2=T3=9T0/4, P1=P2=P3, V2=V3 **.**

S1 dguSis marjvniv myofi 2 moli heliumisaTvis procesi adiabaturia. gvaqvs gantolebebi PV/T=*const* ⇒ **,** sadacγ=Cp/Cv=5/3, γ\_1= 2/3 . amis gamoyenebiT miiReba

V2=V3=(8/27)V0 , P1=P2=P3=(243/32)P0 .

V1=3V0\_2V2=(65/27) V0. PV/T=*const* ⇒ T1=(585/32)T0 .

b) A1 nawilSi moTavsebuli airis mier Sesrulebuli muSaoba aris A2 da A3 nawilebSi moTavsebul airebze Sesrulebul muSaobaTa jami, romelic tolia am airebis Sinagani energiis cvlilebebis jamis (radganac maT ar miiRes siTbo) : .

g) .

**moxrili mili (8 qula)**

V-s formiT moxrili mili, romli moxris kuTxe 60°-ia (ix.nax), uZravad aris damagrebuli. am milis or muxls yofs onkani. vertikalur muxlSi *H* simaRlemde asxamen wyals da Semdeg xsnian onkans, ris Semdegac wyali iwyebs gadasvlas meore muxlSi. CaTvaleT. rom wyali ar ireva da siTbo ar gamoiyofa. ipoveT milSi wylis moZraobis periodi. milis radiusi ucvlelia.

**amoxsna:**

davuSvaT, wylis gadasvlis procesSi misi simaRle marcxena muxlSi aris *x.* maSin marjvena muxlSi gadasuli wylis svetis sigrZea (*H*-*x)*, xolo misi donis simaRlea *(H-x)cosα*. maSin wylis potenciuri energia iqneba

am gamosaxulebis gawarmoebiT miviRebT Zalas sapirispiro niSniT. amitom

es aris harmoniuli rxevis gantoleba, sadac wonasworuli mdgomareoba ( Seesabameba .SemoviRoT gadaxra wonasworobidan: . maSin moZraobis gantoleba miiRebs Semdeg saxes:



es aris cikluri sixSiriT harmoniuli rxevis gantoleba. rxevis amplitudaa . sawyis momentSi wyali wonasworobidan maqsimaluradaa gadaxrili dadebiT mxares. am pirobebSi gantolebis amoxsnaa . es amoxsna aRwers siTxis moZraobas manamde, sanam mTeli siTxe gadava daxril muxlSi. amis Semdeg moZraoba gadaiqceva TanabarSenelebulad (daxrili sibrtyis msgavsad) manamde, sanam wylis simZimis centri ar aRmoCndeba sawyis (*H*/2) simaRleze, ris Semdeg siTxe iwyebs “srials” qveviTken da brundeba vertikalur milSi **.** mTeli moZraobis periodi aris vertikaluri svetis “harmoniulad” nulamde Semcirebis da daxril muxlSi “asrialebis” gaormagebuli jamis toli. pirveli nawili *t*1 ganisazRvreba pirobiT *x*=0, rac gvaZlevs da . periodis meore *t*2 nawilis sapovnelad gaviTvaliswinoT, rom daxril milSi moZraobisas aCqarebis gegmili vertikalurad qveviT mimarTul RerZze aris , simZimis centri Tavdapirvelad simaRlezea, xolo bolos H/2 simaRleze. amitom sapovnelad gvaqvs gantoleba **.** sabolood kuTxis mniSvnelobis gaTvaliswinebiT periodisaTvis miviRebT

**rgoli da qanqara (12 qula)**

m masis foladis mcire burTula Camokidebulia ℓ sigrZis Zafze. mocemuli sistema SegviZlia ganvixiloT rogorc maTematikuri qanqara, romelic asrulebs mcire rxevebs. haeris winaaRmdegoba SegviZlia ugulebelvyoT. burTulas gamosvla rgolis sibrtyidan SegiZliaT ugulebelyoT. wonasworobis mdebareobaSi burTula imyofeba horizontalurad moTavsebuli R radiusis Txeli rgolis centrSi. burTulas aniWeben q muxts, romlis moduli da niSani SeiZleba vcvaloT.

**1. eleqtrostatikuri Zala**

rgols mianiWes dadebiTi niSnis Q muxti, romelic Tanabrad ganawilda masze.

1.1. daxateT rgolis centrze gamaval vertikalur sibrtyeSi mis mier Seqmnili eleqtruli velis Zalwirebis sqematuri suraTi.

1.2. aCveneT, rom rgolis sibrtyeSi centridan mcire r manZiliT (r<<R) daSorebul A wertilSi velis daZabuloba moicema formuliT

sadac rgolis centridan A wertilisaken gavlebuli radius-veqtoria.

***Tu am formulas ver daamtkicebT, misi gamoyeneba mainc SegiZliaT.***

1.3. ipoveT burTulas mcire rxevis periodi. am muxtis ra mniSvnelobebisaTvis xdeba SeuZlebeli rxevebi?

1.4. SeafaseT, maqsimum ramdeni procentiT SeiZleba Seicvalos qanqaras rxevis periodi eleqtrostatikuri manqaniT burTulas da rgolis damuxtvis Sedegad. CaTvaleT, rom rgoli da burTula SegiZliaT damuxtoT toli muxtebiT

**monacemebi:** qanqaras sigrZe ℓ=30 sm, rgolis radiusi R=15 sm. Tqven gankargulebaSia foladis burTula diametriT d=1.0 sm da eleqtrostatikuri manqana, romelic qmnis 25 kv Zabvas. foladis simkvrivea ρ=7.0×103 kg/m3, eleqtruli mudmivaa ε0=8.85×10-12 f/m.

**2. magnituri Zala**

rgoli aRaraa damuxtuli, magram masSi miedineba deni. rgolis centrSi magnituri velis induqciis modulia B. burTula kvlav damuxtulia q muxtiT.

***rgolis centris maxloblobaSi magnituri veli erTgvarovnad CaTvaleT.***

2.1. daxateT rgolis centrze gamaval vertikalur sibrtyeSi mis mier Seqmnili magnituri velis Zalwirebis sqematuri suraTi.

ganvixiloT qanqaras mcire rxevebi. z RerZi mimarTuli iyos rgolis centrSi magnituri induqciis mimarTulebiT. x da y RerZebi iqnebian rgolis sibrtyeSi.

2.2. gamosaxeT burTulas aCqarebis *a*x da *a*y gegmilebi g, ℓ, m, q, B sidideebiT, burTulas x da y koordinatebiT da misi siCqaris vx da vy gegmilebiT.

SeiZleba Cveneba, rom am SemTxvevaSi qanqaras moZraoba aris garkveuli ω cikluri sixSiris harmoniuli rxevis da rxevis sibrtyis garkveuli Ω kuTxuri siCqariT Tanabari brunvis jami.

2.3. naTqvamis Sesabamisad, veZeboT miRebuli gantolebebis amoxsna x=Asinωt⋅cosΩt, y= Asinωt⋅sinΩt saxiT da miviRoT ω da Ω sidideebis gamosaxulebebi.

**amoxsna:**

1.1.



1.2. simetriidan aSkaraa, rom daZabuloba mimarTuli iqneba rgolis centrsa da A wertilze gamavali x RerZis gaswvriv. mcire elementis mier Seqmnili velis daZabulobis gegmili x RerZze aris (ix. nax.)

r/R mcire wevris pirveli xarisxebis SenarCunebiT miiReba miaxloebiTi formula

,,\_” niSani gviCvenebs, rom daZabuloba mimarTulia rgolis centrisken, amitom veqtoruli saxiT formula Semdegnairad Caiwereba:

1.3. wonasworobidan mcire gadaxra t momentSi iyos x(t). rxevis gantolebas eqneba Semdegi saxe:

rxevis cikluri sixSiris kvadratia

xolo periodia

rxevebi SeuZlebeli xdeba, roca

am pirobebSi wonasworobis mdgomareoba aramdgradia.

1.4. daumuxtavi qanqaras SemTxvevaSi rxevis periodia

 , sadac

maqsimaluri potenciali, romelic SeiZleba mivaniWoT burTulas aris ϕ=25 kv, amitom burTulas maqsimaluri muxtia q=4πε0rU=1.4×10-8 k. pirobis Tanaxmad imdenivea rgolis maqsimaluri muxti.

burTulas masaa m=πd3ρ/6=4×10-3 kg. parametris mniSvnelobaa β=2×10-3. is Zalian mcirea, amitom

amrigad periodi SeiZleba Seicvalos maqsimum 0.1%-iT.

2.1.



2..2. Tu burTulas radius-veqtoria, xolo misi siCqare, maSin masze moqmedi Zala iqneba (wonasworobidan gadaxris simciris gaTvaliswinebiT)

niutonis II kanonis Tanaxmad aCqarebis gegmilebisaTvis miiReba:

2.3.

pirveli ori gantolebidan

xolo

Asinωt⋅cosΩt=x, Asinωt⋅sinΩt=y

amitom

2.2. punqtSi miRebul SedegebTan Sedareba gvaZlevs

aq minus niSani Seesabameba rxevis sibrtyis brunvas y RerZidan x RerZisaken umciresi kuTxiT.

Cveulebriv, bolo formulaSi magnituri induqciis Semcveli wevri Zalian mcirea da rxevis sixSireze mcire gavlenas axdens.