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figKv

weÁv#bi Rb#j Mæ t_#KB tR`vWZ®gÚj xi MvZ `vk#K#i i wPŠv-fvebvi we lq wQj Ges wewfbaemgq
`vk#KMY G m#ú#K#ewfbæcKvi gZev` w`#q#Qb|

tRvrvÝ tKc#vi m#h#P Pvi w`#K Mh_#jvi NY#Mvzi m#Fvejx Avwe®vi K#ib| wKŠzG m#Fvejx t_#K
m#h#P Pvi w`#K Mh_#jv Nj#Q Rvbr tM#j I, Nj#vi KviY m#ú#K#tKvb ®úó aviYv cvlqv hvq bv|
ci ewZ#Z weL`vZ weÁvbx m#vi AvBR`vK w#DUB gnvKI m#F Avwe®vi K#ib| Zui G m#F t_#K Avgiv G
NUbvi ®úó e`vL`v cvB|

cW 1

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Dfík

G cW tkłl Avcib

- | gnvKłl P msÁv wj LłZ cvi teb,
- | AwfKłl P msÁv wj LłZ cvi teb,
- | wDUłbi gnvKI mFwU eYv KiłZ cvi teb,
- | gnvKI q a'ełKi gvTv, mgxKiY I GKK wj LłZ cvi teb,
- | K'ıfıwM c×wZłZ gnvKI q a'eK G-Gi gvb wYq KiłZ cvi teb|

7.1.1 gnvKI q AwfKI q (Gravitation and Gravity)

wEL'vZ weÁvbx m'vi AvBR'vK wDUb Awm'e'vi Kłib th, gnmekłi cłZ'Kıw e'K'Yv GłK AcıłK AvKI q Kłi | gnmekłi th tKvb w e'K'Yvi gta' AvKI q ejłK gnvKI qej | thgb: P'ıI młhP ga'Kvi AvKI q ej gnvKI q tKvb e'Z Dci cL'exi AvKI q ejłK AwfKI qej | thgb: Avłcj MvQ t'łK Avłcj Dcłi i w'łK bv wMłq memgq włP cto | Avłcj i Dci cL'exi G AvKI q ej AwfKI q ev gva'vKI q |

7.1.2 wDUłbi gnvKI mF (Newton's law of gravitation)

Ógnmekłi th tKvb w e'z ev e'K'Yv ci 'ıitłK Zv'ıi młhvM mijłiLv eivei AvKI q Kłi | G AvKI q ejłi gvb e'z ev e'K'Yvłtqi fłi i , Ydtłi mgvbgwłZK Ges Gł'ıi ga'Kvi 'łZłi ełMP e'ıbgwłZK | Ó

awi, w e'K'Yvi fi h_vıłtg m₁ Ges m₂ Ges Gł'ıi ga'eZP'ıZłd (wPł 7.1) |

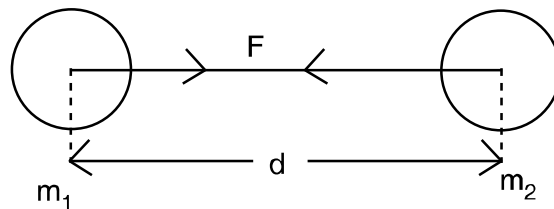
AZGe wDUłbi gnvKI mF Ablyvqx

ej, $F \propto m_1 \times m_2$ [hLb d a'eK]

Ges ej, $F \propto \frac{1}{d^2}$ [hLb m₁ l m₂ a'eK]

AZGe, $F \propto \frac{m_1 \times m_2}{d^2}$ [hLb m₁, m₂ Ges d

mKj i vnk cııeZłkxj]



wPł: 7.1

ev, $F = G \frac{m_1 m_2}{d^2}$ (7.1)

GLvłb, G GKıw mgvbgwłZK a'eK | GłK gnvKI q a'eK ev nekRbıx gnvKI q a'eK ej v nq|

MwVvZK D`niY 1

10 Móg Ges 20 Móg f`ii `w e`K 1 wgvri `fi ivLv ntjv| hw` gnvKl`q a`e`Ki gvB 6.67 × 10⁻¹¹ Nm² Kg⁻² w. wR. Gm GKK nq Zte e`z`w`i g`a` etj i gvB KZ?

mgvavb

Avgir cvB,

$$F = G \frac{m_1 \times m_2}{d^2}$$

$$= \frac{6.67 \times 10^{-11} \times 10 \times 20}{1^2}$$

$$= 13.32 \times 10^{-10} \text{ WvBb/}$$

GLv`b,

$$m_1 = 10 \text{ wKtj vMóg}$$

$$m_2 = 20 \text{ wKtj vMóg}$$

$$d = 1 \text{ wgvri}$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ Kg}^{-2} \text{ w. wR. Gm GKK}$$

7.1.3 gnvKl`q a`eK, G : (Gravitational Constant, G)

hLb m₁ / m₂ = 1 GKK Ges d = 1GKK

ZLb mgvKi Y (7-1) ntZ cvB-

$$F = G \frac{1 \times 1}{1^2}$$

ev, F = G

mZivs GKK f`ii `w e`K Yv GKK `hZi t`K th cvwgvY ej Øviv G`K AcitK AvKl`K Kfi Zv`K gnvKl`q a`eK etj |

7.1.4 gnvKl`q a`e`Ki GKK (Unit of Gravitational Constant)

mgvKi Y 7.1 ntZ cvB-

$$F = G \frac{m_1 m_2}{d^2}$$

$$\text{ev, } G = \frac{F \times d^2}{m_1 \times m_2}$$

$$= \frac{ej \times `iZ_i^2}{fi^2}$$

AZGe, G Gi GKK Nm² Kg⁻²

Gd. wC. Gm c`wZ cvDÚvj - dZ² / cvDÚ² |

7.1.5 G-Gi gvĭv mgxKiY

mgxKiY 7.1 nġZ cvB-

$$[G] = \frac{[F \times d^2]}{[m_1 \times m_2]} = \frac{[MLT^{-2} \times L^2]}{[M^2]}$$

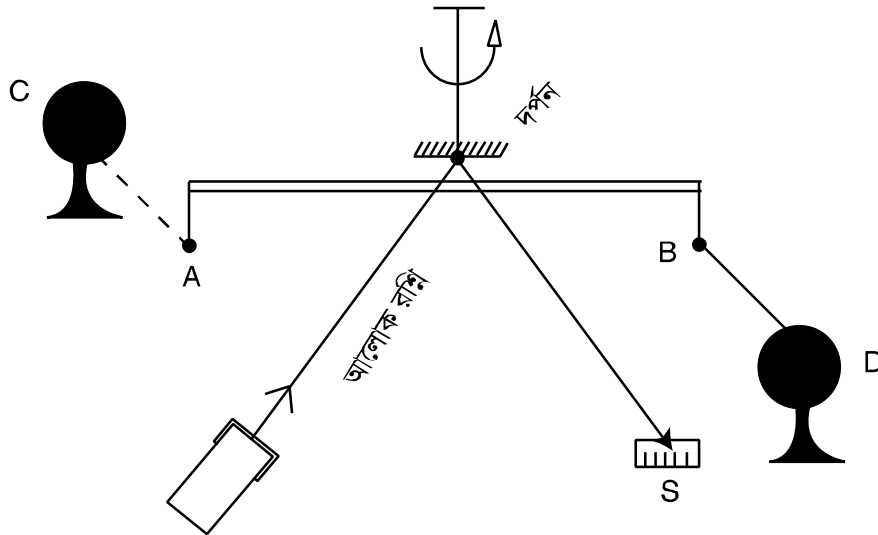
$$[G] = M^{-1} L^3 T^{-2}$$

G-Gi gvB eġġqi cġġZ, thgb fi, AvKvi, AvKwZ. Ges Gġi gaġeZġ gvaġġgi cġġZ, thgb cġġkġZv, cġġYZv, wġ KġġkġZv BZġwġ i Dci wġfġ Kġi bv| G KviġY G-tK mveRbxb aġeK ejv nq|

7.1.6 G-Gi gvB wġYġ (Determination of G)

Kġġġfġġġmi cġġwZ (Cavendish's method): tnbix Kġġġfġġġmi meġġġg 1798 mġġ G-Gi gvB wġYġ Kġi b| wġġG-Gi gvB wġYġ Kġġġfġġġmi cġġwZ eYġv Kiv nġġv|

hġġġ eYġv: Kġġġfġġġmi hġġġ; GKwU nvj Kv j ġġmi " ġġ vġK | ġġġi ġġġġġ-ġġ nvj Kv mxmvi tMj K A I B Sġġġbv vġK (wġġ 7.2) | ġġw GKwU ġġ Aeġ ġb nġZ eġeZġ Zvi ġviv AbġġġKfġġe Sġġġbv vġK | Sġġġ-ġġġi GK cġġġ-GKwU AbġġġK tġġ vġK, hvi mġvġġġ NYġ A_ġ eġeZġ Zġġi i tġvPo tKiv gġcv nq| tMj K ġġġi cvġkġmgvb ġġġġ; ġġ mxmvi tMj K C I D Ggbfġġe ivLv nq thb tMj K Priwġi tKġ ġġġK AbġġġK Zġġ Aeġvb Kġi |



wġġ 7.2

cixġġv: cġġġg C I D eo tMj K ġġġ ġġi mġġġġ tġġġi mġvġġġġ ġġwġi cġġwġK Aeġġġbi cvV wġB| AZ:ci A I B tġvU tMj K ġġġi cvġkġġeo tMj K ġġġ ġġvb Kwġ | G Aeġġġġ ġġġi ġġġġġ-ġġ tMj K I tMj Kġġqi ġġġġ cvġġwġi K AvKlġbi dtġ ġġġ mgvb I wġcixZ hġġġ eġġi mġġ nq| G hġġġ eġġi Rbġ ġġ NġġZ vġK A_ġ eġeZġ Zvi tġvO Lvq| G Aeġġġġ tġġġi mġvġġġġ ġġġi cġġġġ Aeġġġbi cvV wġġġ cġġwġK Aeġġġbi cvġVi mġvġġġġ ġġġi cġġġġ miY wġYġ Kiv nq| G miY I ġġġi ġġNġ mġvġġġġ NYġ tKiv wġYġ Kiv nq| GLb eo tMj KġġqġK ġġwġi cġġġġ Dci ġġ wġcixZ cvġkġġġvb (wġġġ E I F Aeġvb) Kġi cġġġgZ NYġ tKiv wġYġ Kiv nq| meġġġġ G ġġ NYġ tKivYi Mo gvB tġl qv nq|

ami, tQvU tMvj K`yji c0Z`KwUi fi = m
 eo tMvj K`yji c0Z`KwUi fi = M
 cvkvcnk eo l tQvU tMvj K0tqi fvi tKt`f ga`eZP`iZj = d
 AZGe, c0Z`K c0S`-tMvj K0tqi gta` AvKI`ej

$$F = G \frac{mM}{d^2} \dots\dots\dots (1)$$

∴ hM`j i ávgK = ej × 0t`ji evú

$$= G \frac{mM}{d^2} \times l \dots\dots\dots (2)$$

GLv`tb l nt`Q` t0i` N`

hiv` Ny0` tKvY` 0 nq Ges c0Z` GKK Ny0`bi UK`c nq,
 Zte e`eZ0` Zv`i cL`qbx 0t`ji ávgK = τθ (3)

mvg`ve`vq,

$$G \frac{mM}{d^2} \times l = \tau\theta$$

$$\text{ev, } G = \frac{\tau\theta d^2}{Mml} \dots\dots\dots (4)$$

mgxKiY 4-Gi Wvb cvtk`P` mKj gvb Rvbn`vKvq G-Gi gvb tei Kiv hvq|

mvi mst`q|c

gnvKI`0`gnmetk`ji th tKvb`yji e`zYvi gta` AvKI`ej tK gnvKI`0`ej |

AwfKI`0`tKvb e`z` Dci cL`exi AvKI`ej tK AwfKI`0`ej |

gnvKI`0`m`f: gnvmetk`ji th tKvb`yji e`zev e`zYv ci`úitK Zv`i msthvM mij`tiLv eivei AvKI`ej
 Kti | G AvKI`ej tji gvb e`zev e`zYv0tqi f`ii , Ydtji mgvb0vZK Ges Gt`i ga`Kvi`hZji
 e`M`P` e`v`vb0vZK |

gnvKI`0`q a`eK: GKK f`ii`yji e`zYv GKK`hZji t`tK th cwi grY ej 0viv GtK AcitK AvKI`ej
 Kti Zv`tK gnvKI`0`q a`eK e`tj |

c0qvRbxq mgxKiY,

$$\text{gnvKI`0`ej : } F = \frac{Gm_1m_2}{d^2}$$

$$\text{AwfKI`0`ej : } F = \frac{GMm}{d^2} \text{ [GLv`tb } M = cL`exi \text{ fi]}$$

cökvëi gj"vqb

mWk DËti i cçk Wk (v) WY w b

- gnvçtk; th tKvb `W e`KYvi gta" AvKI" ej ntj v-
 K. AwFKI© L. gnvKI© M. AwFKI" Zji Y N. cçej "
- cW ex Ges th tKvb e`z gta" AvKI" ej ntj v-
 K. AwFKI" Zji Y L. AwFKI© M. gnvKI© N. cçUvb
- `W e`KYvi gta" AvKI" ej KYWtqi ga"eZP` iZji-
 K. mgvbgWZK L. e"vbgWZK M. eçMP mgvbgWZK N. eçMP e"vbgWZK
- Gg.tK.Gm cWZtZ G-Gi GKK nt"Q-
 K. ms⁻² L. m³kg⁻¹s⁻² M. m²/kg² N. Nm²kg⁻²

msvWjB cçce

- gnvKI" AwFKI" KvçK etj ?
- wbDUtbi gnvKI" mFw Wj Lç|
- gnvKI" a"eK ej tZ Wk eçSb?
- wçFbæcWZtZ gnvKI" a"eçKi GKK, tj v Wk Wk?
- gnvKI" a"eçKi gvI v mgxKi Yw Wj Lç|

MwWvZK cçce

- `W e`z cçK"KuWi fi 10 Wktj vMög| Dnv" i ci`úi ntZ 1 WgUvi `çi`vcb Ki tj Dnv" i gta" gnvKI" etj i gvb KZ nte? [G= 6.67×10⁻¹¹Nm² kg⁻² Gg.tK.Gm]
- 39.2 Wktj vMög l 15 Wktj vMög fti i `W tMvj çKi tK" 0.2 WgUvi `iZi`vKvKtj GçK AcitçK 98×10⁻⁸ wbDUb etj AvKI" Kti | G Gi gvb wbyç Ki"b|

cW-2

AwfKlR ZjY

Dfík

G cW tkłl Avcvb

- | AwfKlR ZjY 0g0 Gi msÁv wj LtZ cvi teb,
- | AwfKlR ZjY 0g0 Gi GKK I gvT v mgyKiY wj LtZ cvi teb,
- | AwfKlR ZjY 0g0 Gi gvb tei Ki tZ cvi teb,
- | c`v`exi wewfbæ`v`tb AwfKlR ZjYi 0g0 gv`bi wewfbæ`v`vi KviY eY`v`v` Ki tZ cvi teb |

7.2.1 AwfKlR ZjY 0g0 (Acceleration Due to Gravity 0g)

wbDU`bi Mwzi w0Zxq m`f` n`Z Avgiv Rvb, e`z` Dci ej w`uqv Ki tJ ZjYi m`p` nq | AwfKlR GKwU ej | G ej l e`z` Dci w`uqv Kti ZjYi m`p` Ki te | G ZjYB AwfKlR ZjY 0g0 bvtg cwi wPZ | A`f` AwfKlR etj i w`uqv dtj g`f` fite coš`-tKvb e`z` teM ew`x`i nvi`K AwfKlR ZjY etj | AwfKlR ZjY 0g0 Gi GKK Gg.tK.Gm ev AvšR`w`ZK c`x`w`Z`Z - Gi GKK w`u`v`i`/m`2 | Gi gvT v mgyKiY = [LT-2]

7.2.2 AwfKlR ZjYi mgyKiY (Equation of Acceleration Due to Garavity)

g`tb Kwi, c`v`exi fi M Ges e`v`mva`R | m fi wewkó GKwU e`z`c`v`ex c`t`o Aew`Z | Zvntj wbDU`bi gnvKlR m`f` n`Z Avgiv cvB

$$F = G \frac{Mm}{R^2} \dots\dots\dots (1)$$

Avevi, wbDU`bi Mwzi w0Zxq m`f` n`Z Avgiv cvB

$$ej = fi \times ZjY$$

$$\therefore \text{AwfKlR } ej = e`z` fi \times \text{AwfKlR ZjY}$$

$$A`f` F = mg \dots\dots\dots (2)$$

\therefore mgyKiY (1) Ges mgyKiY (2) n`Z cvB

$$mg = G \frac{Mm}{R^2}$$

$$ev, g = \frac{GM}{R^2} \dots\dots\dots (7-3)$$

Dctii mgyKiY n`Z t`Lv hvq th, G l M a`e` i`v`k dtj g-Gi gvb R-Gi Dci w`f`f`k`y, g-Gi gvb e`z` f`ii Dci w`f`f` Kti b`v` | AZGe f`-c`t`oi tKvb w`v`i` 0` `v`tb g-Gi gvb w`v`i` 0, w`K`š`z`-v`b`f`f`` Gi cwi eZ` N`U |

$$c`v`exi fi, M = 5.983 \times 10^{24} \text{ kg}$$

Ges e'vma[®]_R = 6.36 × 10⁶ m ntj Dctii mgxKiY ntZ f₇c₀ g-Gi gvb nq-

$$g = \frac{6.657 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2} \times 5.983 \times 10^{24} \text{ kg}}{(6.36 \times 10^6 \text{ m}^2)}$$

$$= 9.81 \text{ ms}^{-2}$$

D`niY 1: P₇`i fi m c_uexi fi M Gi $\frac{1}{80}$ f_vM I P₇`i e'vma[®] c_uexi e'vma[®]_R Gi $\frac{1}{4}$ f_vM/

P₇`a c₀ AwfKIR Zj₇Yi gvb wby₇ Ki`b/

mgvab: g₇b Kwi, c_uex c₀ AwfKIR Zj₇Yi gvb = g_e Ges P₇`a c₀ = g_m

GB gvb AwfKIR Zj₇Yi mgxKi₇Y eim₇tq

Avgi₇ c_vB, g_e = $\frac{GM}{R^2}$

I g_m = $\frac{Gm}{r^2}$

∴ $\frac{g_m}{g_e} = \frac{m}{M} \times \left(\frac{R}{r}\right)^2$

ck₇by₇ti, M=80m I R=4r

∴ $\frac{g_m}{g_e} = \frac{m}{80m} \times \left(\frac{4r}{r}\right)^2 = \frac{1}{80} \times (4)^2 = \frac{1}{5}$

∴ g_m = $\frac{1}{5}$ g_e

= $\frac{1}{5} \times 9.81 \text{ ms}^{-2} = 1.96 \text{ ms}^{-2}$

7.2.3 AwfKIR Zj₇Y 'g' Gi c_uieZ₇ (Variation of 'g')

AwfKIR Zj₇Y 0g₀ tKvb a^ee i₇nk bq, w₇by₇ wLZ wZb₇w Kvi₇Y Gi gv₇bi wKQyc₇wi eZ₇ N₇U:

1. D`PZvi w₇uqv (Altitude effect)
2. A₇Y₇sk w₇uqv (Latitude effect) Ges
3. c_uexi NY₇ w₇uqv (Rotational effect of the earth)

w₇by₇ wLq, t₇Y eY₇ Kiv nj:

1. D`PZvi w₇uqv

K. c_uex c₀ t₇tk Dcti Aew₇Z `w₇b g : g₇b Kwi, M c_uexi fi Ges R Gi e'vma[®] f₇c₀

AwfKIR Zj₇Y, g = $\frac{Gm}{R^2}$

h₇w e₇zc_uex c₀ ntZ h D`PZiq Ae₇vb K₇ti Z₇te Gi Dci w₇uqv₇ Z AwfKIR₇ Zj₇Y-

g₁ = G $\frac{M}{(R + h)^2}$ (7.4)

mgxKi Y 7.4 Ges 7.3 nřZ cıB-

$$\frac{g_1}{g} = \frac{R^2}{(R+h)^2} = \frac{1}{\left(1 + \frac{h}{R}\right)^2}$$

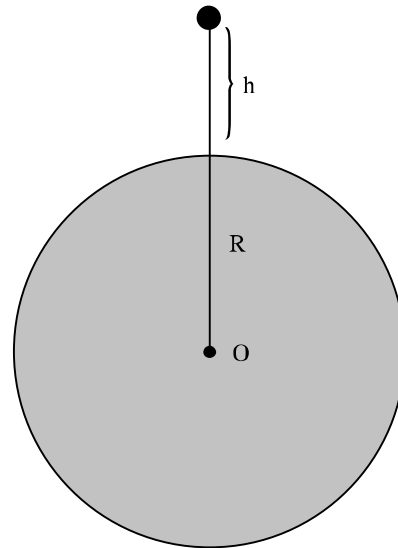
$$\left(1 + \frac{h}{R}\right)^{-2} = 1 - \frac{2h}{R}$$

[wC`x Dccvř`i mrvřh` ve`Z Kři Ges thřnZřh << R

ZvB $\frac{h}{R}$ Gi D`PLvZmgř Dřcřv Kři |]

ev, $g_1 = g \left(1 - \frac{2h}{R}\right)$ (7.5)

$\therefore g_1 < g$



wPř 7.3

D`niY 2

fřcř nřZ KZ DřP řMřj řmLvKvi AřFKIřq ZjřYi gvb řcřř AřFKIřq ZjřYi gřbi GK kZřsk nř| cı exřK 6.38×10^8 řm.řg e`vřřřřř řMřj K gřb Ki`b|

mgvavb

Ařgi v cıB, $g = \frac{GM}{R^2}$ (1)

GLvřb, $G = gmvKlřq a^řeK$

$M = cı exř ři$

$R = cı exř e`vřřřřř$

$g = řcřř AřFKIřq ZjřY$

$g' = h D`PZřq AřFKIřq ZjřY = \frac{g}{100}$

Ges $g' = \frac{GM}{(R+h)^2}$ (2)

(1) bs 1 (2) bs mgxKi Y Ařřřřřř $g'/(R+h)^2 = gR^2$

ev, $\frac{g}{100} (6.38 \times 10^8 + h)^2 = g \times (6.38 \times 10^8)^2$

ev, $(6.38 \times 10^8 + h) = \sqrt{100 \times (6.38 \times 10^8)^2}$
 $= 10 \times 6.38 \times 10^8$

ev, $h = (10-1) \times 6.38 \times 10^8$

$\therefore h = 57.42 \times 10^8$ řm.řg

AZGe, f₇-çô Dcti AwfKIR ZjıYi gvb Kg| f₇-çô t₇K hZ Dcti I Vv hvq AwfKIR ZjıYi gvb ZZ KgıZ _vıK|

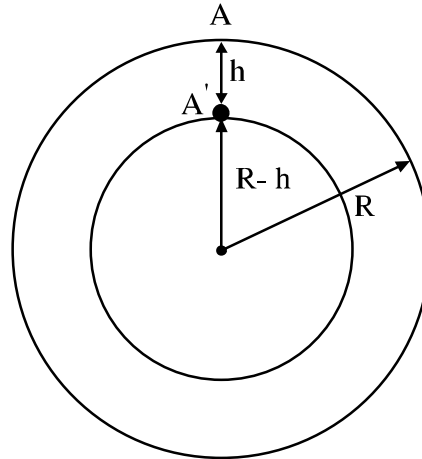
L. cılexi Afıŝi AewZ tkvb vıtb g : gıtb Kwi, f₇-çô nıZ h Mfxıi GKıU e⁻zAewZ| hw cılexi e^ııvıa^ı nq, Zte cılexi tkv^ı nıZ Gi^ı iZj (R-h) (ıPı 7.4) | (R-h) e^ııvıa^ı nıko cılexi Astki AvqZb = $\frac{4}{3} \pi (R-h)^3$ | hw cılexi Mo NbZjı p nq, Zte (R-h) e^ııvıa^ı nıko cılexi Astki fi, $M_1 = \frac{4}{3} (R-h)^3 \times \rho$

mızi vs fçô t₇K h Mfxi Zıv AwfKIR ZjıY g₁ nıj -

$$g_1 = \frac{GM_1}{(R-h)^2}$$

$$= \frac{G \times \frac{4}{3} \rho (R-h)^3 \times r}{(R-h)^2}$$

$$= \frac{4}{3} \pi G \rho (R-h) \dots \dots \dots (7.6)$$



ıPı: 7.4

Avıvı Rıvb, cılexi fi M nıj f₇-çô AwfKIR ZjıY

$$g = \frac{GM}{R^2}$$

$$\frac{g_1}{g} = \frac{\frac{4}{3} \rho Gr (R-h)}{\frac{GM}{R^2}}$$

$$= \frac{\frac{4}{3} \rho Gr (R-h)}{G \times \frac{4}{3} \rho R^3 \times r}$$

$$= \frac{R-h}{R}$$

$$= 1 - \frac{h}{R}$$

$$\therefore g_1 = g \left(1 - \frac{h}{R}\right) \dots \dots \dots (7.7)$$

AZGe, f₇-çô nıZ ıbtP AwfKIR ZjıYi gvb Kg| f₇-çô nıZ hZ ıbtP hvı qı hvq AwfKIR ZjıYi gvb ZZ KgıZ _vıK|

M. c`v`exi tK`Á`AwfKl`q Zj`Y: h`v` tKv` e`z`c`v`exi tK`Á`Aew`Z nq A`R = h nq, Zte c`v`exi tK`Á`AwfKl`q Zj`Y g₀ a`ti mgv`Kiy 7.6 t`K`c`v`B-

$$g_0 = \frac{4}{3} \pi G \rho (R-h) = 0 \quad \therefore g_0 = 0$$

∴ c`v`exi tK`Á`AwfKl`q Zj`Yi gvb kb`|

Dc`ti i Av`tj v`Pbv` n`Z j` q` Kiv` hvq` th, f_z-c`p` n`Z Dc`ti A`ev` v`b`P` 0g`0 Gi gvb` Kg` n`te Ges` c`v`exi tK`Á`A0g`0 Gi gvb` kb`| AZGe` f_z-c`p`0B` 0g`0 Gi gvb` met`P`tq` tevk`|

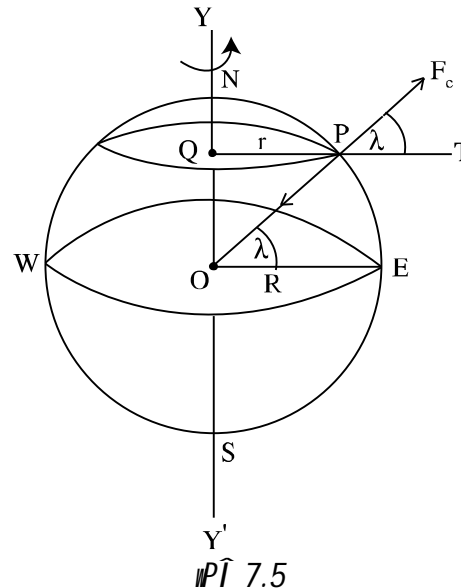
2. A`q`v`sk` v`m`q`v`

Av`g`iv` Rvb`, c`v`exi Av`Kv`Z` Kgv` v` t`j` e`y` g`Z` A`R` D`E`i` I` v`q`v` t`gi` v`K`Q`v` P`ic`v` Ges` v`el`y`-e`v`m` t`gi`-e`v`m` A`t`c`q`v` 27` gv`Bj` ep`E`i` | A`R` v`el`y` t`i`Lvq` c`v`exi` e`v`m`v`a`met`P`tq` tevk`| v`el`y` t`i`Lvi` v`K` n`Z` h`Z` t`gi` i` v`K` hv`l` q`v` hvq` e`v`m`v`a`ZZ` K`g`t`Z` v`t`K`| m`z`iv`S` v`el`y` A`A`t`j` e`v`m`v`a`tevk` n`l` hvq` 0g`0 Gi gvb` Kg` v`t`K` Ges` t`gi` A`A`t`j` e`v`m`v`a`Kg` n`l` q`v`q` 0g`0 Gi gvb`l` met`P`tq` tevk` n`q`|

3. c`v`exi NY`b` v`m`q`v`

c`v`ex` v`b`R` A`t`q`v`i` P`v`i` v`t`K` N`j`vi` d`t`j` Av`v`y`K` M`v`Z`i` m`v`p` n`q`| c`v`exi` NY`b`i` d`t`j` f_z-c`p`0i` e`v`z` NY`b` M`v`Z`i` m`v`p` n`q`| d`t`j` D`v`v`Z` t`K` v`eg`v`x` e`t`j`i` m`v`p` n`q` hv` e`v`t`K` e`E` c`t`_i` e`v`m`v`a`e`ivei` v`Q`U`v`K` d`t`j`vi` t`P`0v` K`ti`|

d`t`j` t`K` v`eg`v`x` e`j` AwfKl`q` e`t`j`i` v`ec`i`x`Z` K`v`R` K`ti`, K`v`t`RB` AwfKl`q` Z`j`Y` n`v`m` c`v`q`| t`gi` A`A`j` A`t`c`q`v` v`el`y` A`A`t`j`i` e`v`z`ep`E`i` e`v`m`v`a`P` e`E`v`K`v`i` c`t`_i` N`j`i` e`t`j` H` v`t`b` t`K` v`eg`v`x` e`j` l` tevk` n`q`| K`v`t`RB` 0g`0 Gi gvb` t`gi` A`A`t`j` met`P`tq` tevk` Ges` v`el`y` A`A`t`j` met`P`tq` Kg` n`te`|



avi, m` f`ti` i` GKv`U` e`v`z`f_z-c`p`0` λ` A`q`v`st`ki` (D`E`ti) p` v`e`v`j`Z` A`ew`Z`| c`v`exi` NY`b`i` R`b` e`v`t` r` e`v`m`v`a`P` e`E` ω` t`K`S`v`Y`K` t`e`t`M` N`j`v`Q`| e`v`z` D`ci` v`m`q`v`i`Z` t`K` v`eg`v`x` e`j` T` n`t`j`, T = mrv²

∴ f_z-c`p`0i` e`v`B`ti` i` v`t`K` t`K` v`eg`v`x` e`t`j`i` D`c`v`sk`-

$$F_c = T \cos \lambda = mrv^2 \cos \lambda = m\omega^2 R \cos^2 \lambda \quad (\because r = R \cos \lambda)$$

$$\text{Avevi, e`v`z` D`ci` f_z-t`K`Á` i` v`t`K` c`v`exi` Av`Kl`v` e`j, } F = Mg = m \frac{GM}{R^2}$$

$$\text{AZGe, e`v`z` D`ci` v`m`q`v`k`j` j` v`ä` e`j, } F_\lambda = F - F_c = \frac{GMm}{R^2} - m\omega^2 R \cos^2 \lambda$$

P we` tZ f-tK` a AwfgyL AwfKIR ZjY g_λ ntj

$$F_{\lambda} = mg_{\lambda} = \frac{GMm}{R^2} - m\omega^2 R \cos^2 \lambda$$

$$\therefore g_{\lambda} = \frac{GM}{R^2} - \omega^2 R \cos^2 \lambda \dots \dots \dots (7.8)$$

i) weIy AAtj, λ = 0° ∴ g_λ = $\frac{GM}{R^2} - \omega^2 R$ [Q cos 0° = 1]

ii) tgi" AAtj, λ = 90° [∴ cos90° = 0]

$$\therefore g_{\lambda} = \frac{GM}{R^2}$$

∴ KtRB ōgō Gi gvb tgi" AAtj metPtq tenk Ges weIy AAtj metPtq Kg|

mvi mst¶c

AwfKIR ZjY: AwfKI etj i μμqi dtj gy fite coš-tKvb e`z teM ewxi nvi tK AwfKIR ZjY etj |

cōqvRbıq mgıKiY-

f-tçō AwfKIR ZjY: $g = \frac{GM}{R^2}$

cōkēi gj`ıqb

K. mWk Dētii cıtk wK wPı (√) w b |

1. AwfKIR ZjY ōgō Gi mgıKiY ıbtPi tKıvııW?

$$K. g = G \frac{m_1 m_2}{d^2} \quad L. g = \frac{GMm}{d^2} \quad M. g = \frac{GM}{R^2} \quad N. g = \frac{GM}{R^2}$$

2. AwfKIR ZjY ōgō Gi gvb ntj v-

$$K. 9.81 \text{ ms}^{-2} \quad L. 7.7 \text{ ms}^{-2} \quad M. 8.91 \text{ cms}^{-2} \quad N. 9.7 \text{ cms}^{-2}$$

L. msv¶B cōke

1. AwfKIR ZjY ōgō ej tZ wK etSb?

2. AwfKIR ZjYi mgıKiY I gvb ıj Lı|

M. MwıwZK cōke

1. cıex cōō GKııW tj vtKi IRb 40 wKtj vMög-IRb IRb ntj P`a cōō Dnvi IRb KZ nte| cıexi fi Pt`ı fııi 41 , Y Ges cıexi e`ııııvaPı`ı e`ıııııtaP 4 , Y|

2. cıexi e`ıııııva 6.38 × 10⁸ tm.ıg I gnvKıııg a`eK G = 6.67 × 10⁻⁸ ıııııRGm GKK ntj cıexi Mo NbZjııııııı Ki | g = 981 tm.ıg/tm²

3. cıex cōō GKııW e`z IRb 90 wKtj vMög IRb | gıj Mōni cōō Dnvi IRb KZ nte? gıj Mōni fi cıexi fııi $\frac{1}{4}$ fııı Ges e`ıııııva cıexi e`ıııııtaP AıaR |

cW-3

fi, IRb, NbZ;I fvi†K>`a

D†Ík`

G cW †k†I Avıv

- | IR†bi msÁv vj LtZ cvi †eb,
- | fi | IR†bi g†a` cv_ℝ` nbY@ Ki†Z cvi †eb,
- | fi | NbZ;nbY@qı mgıKıY vj LtZ cvi †eb,
- | AwfKIR †K†`ı msÁv vj LtZ cvi †eb,
- | mıy e`z fvi†K>`a nbY@ Ki†Z cvi †eb|

7.3.1 fi | IRb (Mass and weight)

fi : fi n†`Q RoZvi cwi gıv A_ℙ †Kıv e`z tetMi cwi eZ†K evav †`I qvi cwi gıvB n†`Q Zvi fi | GıU GKıU †`jvi iıvK| c_ℓ exı mKj `††b fi mgıv _††K| fi c`v†_ℙ GKıU mıvıY ag† f†ıı GKk Gg.†K.Gm ev Gm.AvB c×ıZ†Z †K†j vMıg, m.ıR.Gm c×ıZ†Z Mıg Ges Gd.ıc.Gm c×ıZ†Z cvDÚ| G†K mıvıYZ ŪmŪ ev ŪMŪ Ūvıv cKıv Kıv hıvq| Gi gv†v n†jv [M.]|

IRb : †Kıv e`zK c_ℓ ex th ej Ūvıv Zvi †K†`ı ı††K Ū††b ev AvKıℙ K†ı Z††K H e`z IRb etj | GıU GKıU ††ıı iıvK| c_ℓ exı mKj `††b IRb mgıv _††K bv| G†K mıvıYZ ŪwŪ Ūvıv cKıv Kıv hıvq|

Aveı, IRb, w= fi x AwfKIR ZııY

eV, w=mg

ııwfbæ`††b ŪgŪ-Gı gvıb ııwfbæ††j, ııwfbæ`††b IR†bi | gvıb ııwfbæ†† IRb c`v†_ℙ mıvıY ag†bq| e`ı IRb _vK†Z cv†ı Aveı bv| _vK†Z cv†ı | thgb c_ℓ ex †_†K eü Dc†ı gıvK†b` e`z IRb bvB|

D`niY-1

GKıU e`z fi 10 †K†j vMıg| hıv` AwfKIR†ı ZııY 9.8 ıgŪvı /tm.² nq Z†e e`ııı IRb emııı Kı`b| mgıvıvıv:

$$\begin{aligned}
 \text{Avgıvıv Rıvıv, } w &= mg = 10 \text{ kg} \times 9.8 \text{ ms}^{-2} . \text{ th†nZzGL††b } m = 10\text{kg Ges } g = 9.8 \text{ ms}^{-2} \\
 &= 98 \text{ kg.ms}^{-2} \\
 &= 98 \text{ Newton}
 \end{aligned}$$

fi I IRtbi gta" cv_R" (Distinction Between Mass and Weight)

fi	IRb
1. fi nt"Q RoZvi cwi gvc, tKib e-ž tetMi cwieZtK evav t"l qvi cwi gvcB nt"Q Zvi fi	1. tKib e-tK cwe ex th ej Øviv Zvi tKt"i w-tK Uvtb ev AvKIØ Kti ZvtK H e-ž IRb etj
2. fi GKIU t-j vi i vnk	2. IRb GKIU tFKØi i vnk
3. AvšRØZK c×iZtZ fti i GKK wKtj vMög	3. AvšRØZK c×iZtZ IRtbi GKK wDUB
4. fi meP GKB_vtK	4. IRb wevfbe-vtb wevfbd
5. fi ØgØ Gi Dci wbfPkj bq	5. IRb ØgØ Gi Dci wbfP Kti
6. fi e-ž GKIU wR^, Y Dtñx Kti	6. IRb cwieZØkj mživs IRb Øviv tKej gvI e-ž wR^, Y Dtñx Kti bv
7. fi mavi Y wv³ i mrvth" cwi gvc Kiv nq	7. IRb w-ús wv³ i mrvth" cwi gvc Kiv nq

7.3.2 e-ž IRtbi cwieZØ (Variation of weight of a Body)

Avgi v Rwb, IRb $w = mg$

GLvtb, $m = e-ž fi$

Ges $g = AvfKIR Zj Y$

e-ž fi a'e i vnk | AZGe IRb AvfKIR ZjtYi (g) Dci wbfPkj | ØgØ Gi gvb thLvth tenk e-ž IRbI tmLvth tenk | Avevi ØgØ Gi gvb thLvth Kg e-ž IRbI tmLvth Kg, mživs wely AÄtj e-ž IRb tgi" AÄj Atcŋv Kg |

f-cØ ntZ Dcti A_ev wtp wbtj e-ž IRb f-cØi IRb Atcŋv Kg nte |

7.3.3 cwe_xi fi I NbZj (Mass and Density of the Earth)

awi, cwe_xi fi I e"vma^h_vµtg M I R. cwe_xi cto m fti i GKIU e-ž Aew-Z |

∴ cwe_xi I H e-ž gta" gnvKIØej ,

$$F = G \frac{Mm}{R^2}$$

Avevi wDUBi Mwzi wZxq mF ntZ cvB-

$$ej = fi \times Zj Y$$

ev, $F = mg$

$$\therefore F = mg = G \frac{Mm}{R^2}$$

$$\text{ev, } M = \frac{gR^2}{G} \dots \dots \dots (7.9)$$

c`l`exi NbZj

$$c_{\text{exi NbZj}} \rho n_{\text{tj}}, \rho = \frac{fi}{AvqZb} = \frac{M}{\frac{4}{3}\pi R^3} = \frac{3M}{4\pi R^3}$$

$$Avevi, M = \frac{gR^2}{G}$$

$$\therefore c_{\text{exi NbZj}} = \frac{3gR^2}{4\pi G R^3} = \frac{3g}{4\pi GR} \dots \dots \dots (7.10)$$

D`niY-1

c`l`exi fi nbYq Ki`b|

$$Avgiv Rmb, c_{\text{exi fi}}, M = \frac{gR^2}{G}$$

GLv`tb, g = 9.8 ms⁻², R = 6.4 × 10⁶m Ges G = 6.7 × 10⁻¹¹ Nm²Kg⁻²

$$\therefore M = \frac{9.8\text{ms}^{-2} \times 6.4 \times 10^6 \text{m}^2}{6.7 \times 10^{-11} \text{Nm}^2 \text{kg}^{-2}} = 6.0 \times 10^{24} \text{kg}$$

D`niY-2

c`l`exi NbZj nbYq Ki`b|

$$Avgiv Rmb, c_{\text{exi NbZj}}, \rho = \frac{3M}{4\pi R^3}$$

GLv`tb, M = 6.0 × 10²⁴ kg ;

π = 3.14

R = 6.4 × 10⁶ m

$$\therefore \rho = \frac{3 \times 6.0 \times 10^{24} \text{ kg}}{4 \times 3.14 \times (6.4 \times 10^6 \text{ m})^3} = 5.5 \times 10^3 \text{ kgm}^{-3}$$

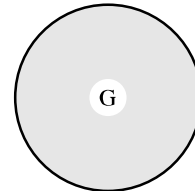
7.3.4 AvfKIqK`a (Centre of Gravity)

Avgiv Rmb, c`Z`K e`zAmsL` KYvi mgb`q MmVZ| Avevi c`Z`KuU KYvB c`l`exi tK`i`i w`tK AvfKIq ej Øviv AvKó.nq| ci ci Aew`Z` w`d KYvi `t`Zji Z`bvaq c`l`exi tK`a`n`Z Gt`i`i`Zi; AnaK nl qvq KYv, w`j i Dci c`l`exi AvKIq ej ci`úi mgn`st`vj l mgyx etj aiv nq (wPÎ 7.6K)| G mg`-mgn`st`vj etj i j`wä cvl qv hvq| G j`wä ej B e`z` I Rb| GLb e`w`d`tK Nvj`tq (wPÎ 7.6L) th tKvb Ae`v`tb tbqv tnvK bv tKb GKB j`wä cvl qv hvte| G` w`d Ae`v`tb e`z` I Rb GKB we`y`GÖ w`tq w`lqv Ki`te|

7.3.5 mlyg e`ž AvfKI`K`a ev fvi`K`a wYq (Determination of Centre Gravity of Symmetrical Bodies)

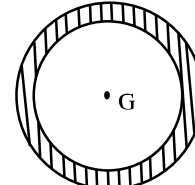
mlyg I mij R`vngwZK AvKvi wewkó e`ž fvi`K`a`Gi AvKvi t`tL wYq Kiv hvq| h_v-

1. mlyg tMj`K`i fvi`K`a`Gi R`vngwZK tK`Aew`Z [wPÎ 7.8 (K)]



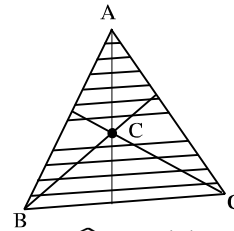
wPÎ 7.8 (K)

2. eFvKvi cvZ ev w-s-Gi fvi`K`a`Gi R`vngwZK tK`Aew`Z [wPÎ 7.8 (L)]



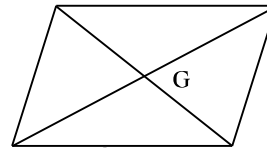
wPÎ 7.8 (L)

3. wî fRvKwZ. cv`Zi fvi`K`a`Gi ga`gvÎtqi tQ` wew`žZ Aew`Z [wPÎ 7.8 (M)]



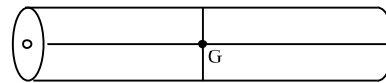
wPÎ 7.8 (M)

4. mvgšwiK cv`Zi fvi`K`a`Gi KY`tqi tQ` wew`žZ Aew`Z [wPÎ 7.8 (N)]



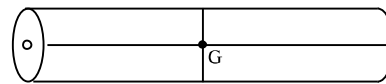
wPÎ 7.8 (N)

5. GKwU mlyg I mij `U ev Zv`ti fvi`K`a`Gi A`t`qi ga` wew`žZ Aew`Z [wPÎ 7.8 (O)]



wPÎ 7.8 (O)

6. wmwj Úv`ti fvi`K`a`Gi A`t`qi ga` wew`žZ Aew`Z [wPÎ 7.8 (P)]



wPÎ 7.8 (P)

mvi mst`q|c

I Rb: tKvb e`žK c`w`ex th ej Øv`v Zvi tK`A`w` t`K Úv`tb ev AvKI`K`i K`ti Zv`tK H e`ž I Rb e`tj | AvfKI`K`a`ev fvi`K`a`? GKwU e`žK th fiv`eB ivLv tnvK bv tKb, Gi I Rb GKwU wv`w`Ø wew`y` t`q w`uqv K`ti, G tK`A`K fvi`K`a`ev AvfKI`K`a`e`tj |

c`q`vRbxq mgvKiY:

$e`ž I Rb t w = mg$

$c`w`exi fi t M = \frac{gR^2}{G}$

$c`w`exi NbZ;t \rho = \frac{3g}{4\pi GR}$

cökvëi gj'vqb

K. mWVK DEÿi i çvçk WUK WPy (√) W b

1. fÿi i GKK WK?

- K. WKÿj vMög L. WKÿj vMög-I Rb M. WbDUB N. AvM®

2. IRÿbi GKK WK?

- K. WbDUB L. Rj M. WKÿj vMög N. AvM®

3. çW_exi fÿi i mgxKi YWU WK?

- K. $M = gmR^2$ L. $M = \frac{gm}{R^2}$
 M. $M = \frac{m}{gR^2}$ N. $M = \frac{gR^2}{G}$

4. çW_exi NbÿZji mgxKi YWU WK?

- K. $\rho = \frac{3p}{4gGR}$ L. $\rho = \frac{3g}{4\pi GR}$
 M. $\rho = \frac{4g}{3\pi GR}$ N. $\rho = \frac{4G}{3gGR}$

L. msWÿB çöce

1. fi I I Rb KvçK etj?
2. e^{-ÿ} I Rb çW_exi tKv_vq meÿPtq teWk I tKv_vq meÿPtq Kg?
3. çW_exi fi I NbÿZji mgxKi Y`Wÿ Wj Lÿ|
4. AwFKI R tKÿ`ÿ msÁv Wj Lÿ|

M. MwvWZK çöce

1. 25 Mög fi weWkó GKWU e^{-ÿ}K 9.8 WgUvi/tm² AwFKI Rq ZiÿYi tKvb`vçb Wbçq tMÿj Gi I Rb KZ nÿe?

cW-4

gnvKIᄁ etj i tᄁᄁᄁ vevfbáw, Kwlᄁ Dcmā, gᄁᄁ telm i tKcjᄁᄁ mĤ

Dᄁᄁk`

G cW tᄁᄁ Ávcv

- | gnvKIᄁ tᄁᄁ, cᄁej` i vefᄁei msÁv wj LtZ cvitᄁb,
- | wᄁ`yᄁᄁ Rb` gnvKIᄁ vefe wYᄁ KiᄁZ cvitᄁb,
- | Kwlᄁ Dcmāni tᄁᄁᄁ AveZᄁKvj i D`PZvi gᄁᄁ m`úK`vcbKvix mgxKi Yw wj LtZ cvitᄁb,
- | gᄁᄁ tetMi msÁv i mgxKi Y wj LtZ cvitᄁb,
- | f,w`i Dcmāni eYᄁv KiᄁZ cvitᄁb,
- | Kwlᄁ Dcmān cᄁ`ex cᄁ`wᄁY Kivi mgq gnvkb`Pvix i RbnxbZv Abyᄁe Kᄁib tKb Zv e`vL`v KiᄁZ cvitᄁb,
- | tKcjᄁᄁ mĤ, wj wj LtZ i eYᄁv KiᄁZ cvitᄁb|

7.4.1 gnvKIᄁ tᄁᄁ, cᄁej` i vefe (Gravitational field, Intensity and Potential)

gnvKIᄁ tᄁᄁ: tKvb e`zᄁv e`mgᄁni Pviw tK hZ`i chS-Gi gnvKIᄁ ej AbyZ nq, tm AĀj tK H e`z` gnvKIᄁ tᄁᄁ etj |

gnvKIᄁ cᄁej`: gnvKIᄁ tᄁᄁᄁ tKvb wᄁ`jZ GKK fᄁi GKw e`z`vcb Kiᄁj, e`w tm AvKIᄁ ej Abyᄁe Kᄁi, ZtK H tᄁᄁᄁ i`b H wᄁ`j ZxeZv ev cᄁej` etj |

e`vL`v: awi, GKw ,i`fvi e`z` fi M₁ Ges e`wᄁi fviᄁK`nᄁZ r`ᄁZj m fᄁi Aci GKw e`z` AvᄁQ|

$$gnvKIᄁ etj i mĤ Abyᄁᄁi AvKIᄁ ej = \frac{GM}{r^2}$$

$$m = 1 \text{ GKK } nᄁj,$$

$$AvKIᄁ ej = \frac{GM \times 1}{r^2} = \frac{GM}{r^2}$$

$$G \text{ ej } B \text{ cᄁej` | } awi \text{ cᄁej` } = E$$

$$\therefore E = \frac{GM}{r^2} \dots \dots \dots (7.11)$$

gnvKIᄁ cᄁej` GKw tᄁᄁw i vᄁk| Gi w`K nᄁ`Q epĒi fᄁi e`z` fviᄁK`Avfᄁy| AvŠRᄁZK c`wZᄁZ Gi GKK NKg⁻¹|

gnvKIᄁ vefe: Amxg`i-Zj nᄁZ GKK fᄁi tKvb e`z` gnvKIᄁ tᄁᄁᄁ tKvb wᄁ`jZ AvbᄁZ th KvR KiᄁZ nq ZvK H tᄁᄁᄁ H wᄁ`j gnvKIᄁ vefe etj |

awi, m fᄁi GKw e`z` Amxg t`ᄁK gnvKIᄁ tᄁᄁᄁ tKvb wᄁ`jZ AvbᄁZ w cwi ᄁvY KvR m`úbc nq|

∴ H we`y gnvKI q wefe

$$v = \frac{W}{m} \dots \dots \dots (7.12)$$

Amx̄tg gnvKI q wefe kb` aiv nq|

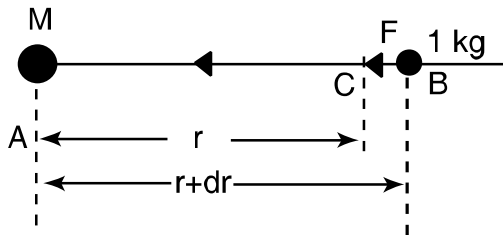
gnvKI q wefe GKIU t`j vi i vnk| AvšR0ZK c×wZtZ KvRi GKK Rj Ges f̄ii GKK wKtj vM0g| mZ̄ivs mgyKIY (7.12) n̄Z wef̄ei GKK cvB Rj/wKtj vM0g mst̄q̄tc AvšR0ZK c×wZtZ Gi GKK Jkg⁻¹|

7.4.2 we`y f̄ii Rb` gnvKI q wefe (Gravitational Potential Due to Point Mass)

avi, A we`jZ M f̄ii GKIU e`zAew`Z| A n̄Z r` t̄ZjB GKIU we`y B we`jZ wefe wBY q KiZ n̄te (wP̄ 7.9)| AB thvM Kw|

B we`jZ GKK fi vcb Kitj Zvi Dci w̄uq̄kij gnvKI q ej,

$$F = G \frac{M \times 1}{r^2} = \frac{GM}{r^2}$$



wP̄ 7.9

Gi w`K BA eivei|

avi, B we`jZ wefe v. GLb GKK f̄ii e`w h̄w` M f̄ii e`z AvKI q ej F-Gi dtj AwZ q̄z` t̄Zjdr m̄ti C we`jZ Av̄tm,

Zte, m̄úw`Z K̄vR = F.dr

GB m̄úw`Z K̄vRB n̄te wef̄ei c̄wieZ0 dv,

m̄Z̄ivs

$$\begin{aligned} dv &= \mathbf{F} \cdot d\mathbf{r} \\ &= F dr \cos 0^\circ \text{ [ej l miY GKB w`tk]} \\ &= F dr \end{aligned}$$

GLb G mgyKI Yt̄K r = ∞ t̄t̄K r = r G m̄x̄vi ḡta` mgyKj b K̄ti B we`jZ wefe v cvB|

$$\begin{aligned} \therefore V &= \int_{\infty}^r F dr \\ &= \int_{\infty}^r \frac{GM}{r^2} dr \end{aligned}$$

$$\begin{aligned}
 &= GM \int_{\infty}^r \frac{dr}{r^2} \\
 &= GM \left[-\frac{1}{r} \right]_{\infty}^r \\
 &= GM \left[-\frac{1}{r} + \frac{1}{\infty} \right] \\
 &= -\frac{GM}{r}
 \end{aligned}$$

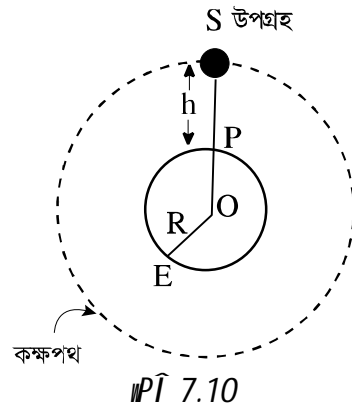
gnvKlÍq wefe mtePP nte Amxg Ges Amxg Gi mtePP gvb kb` | Amxg ntZ hZB t`qT m`pKvix e`wUi w`tk GmMq Avmte Gi gvb KgZ`_vKte A`F FYvZK nte |

7.4.3 Kúlg DcMh (Artificial Satellites)

th mKj gnvkb`hvb w`w` K`qct` t`tk c`exK c`w`qY Kti Zv`i Kúlg DcMh etj | 1957 mtj i 4Vv A`zvei imkqvi weÁvbxiv me`g gnvk`b` GKwú Kúlg DcMh cvVvb | Gi bvg `úyubK-1 | cieZ`Z Avtgwi Kvb weÁvbxiv 1958 mtj gnvk`b` GKwú Kúlg DcMh cvVvb | Gi bvg G-`p`y`ar-1 | cix`qvi mnvth` t`Lv tM`Q th, GKwú e`K c`ex c`p t`tk c`q 930km Dcti Ztj f`ctoi mgvš`-ivtj 8.05 kms⁻¹ nZ 11.1 kms⁻¹ teM gnvk`b` D`qcb Kiti, Zv c`exK c`w`qY Kite | w`z`b` `fi i iK`Ui mnvth` Kúlg DcMh`K w`w` D`PZvq Ztj cti f`ctoi mgvš`-ivtj w`w` teM t`qv nq | dtj Kúlg DcMh`wú c`exi Pvi cvtk NjZ`_v`K |

AveZ`Kvj I D`PZvi gta` m`úK`

ami, m fti i GKwú Kúlg DcMh v teM c`exK c`w`qY Kti | Gi K`qct`i D`PZv h (w`T 7.10) |



g`b Kwi,

$$c`exi e`vma`R I c`exi fi =M |$$

∴ DcMhni Dci Kvh`Z-

$$tK`g`y`x ej = \frac{mv^2}{(R+h)} \dots \dots \dots (1)$$

$$Ges AwfKI`ej = \frac{GMm}{(R+h)^2} \dots \dots \dots (2)$$

c`exi AwfKI`ej B tK`g`y`x etj i thvMv t`q hvi dtj DcMh`wú K`qct`_v`K |

mgxKi Y 1 l 2 nıZ cıB-

$$\frac{mv^2}{(R+h)} = \frac{GMm}{(R+h)^2}$$

$$e\text{v}, v^2 = \frac{GM}{(R+h)}$$

$$\therefore v = \sqrt{\frac{GM}{(R+h)}} \dots \dots \dots (7.13)$$

awi, DçMöni tKŞıYK teM ω Ges AveZö Kij T, Zvntj -

$$v = \omega (R + h) = \frac{2\pi}{T} (R+h) \dots \dots \dots (7.14)$$

mgxKi Y 7.13 Ges 7.14 bs tıK cıB-

$$\frac{2\pi (R+h)}{T} = \sqrt{\frac{GM}{(R+h)}}$$

$$e\text{v}, \frac{4\pi^2 (R+h)^2}{T^2} = \frac{GM}{(R+h)} \quad [Efq cıK eMöKti cıB]$$

$$e\text{v}, (R+h)^3 = \frac{GMT^2}{4\pi^2}$$

$$e\text{v}, (R+h) = \left(\frac{GMT^2}{4\pi^2} \right)^{\frac{1}{3}}$$

$$\therefore h = \left(\frac{GMT^2}{4\pi^2} \right)^{\frac{1}{3}} - R \dots \dots \dots (7.15)$$

D`niY-1

GKıU Kılç DçMöni cıex çöi Ly ıbKıU Aeıvb Kti b`bZg KZ tetM eEıKıti cıexi Priw`K çöıY KiZ cıte?

[cıexi eıvıaR = 6.4 × 10⁶ ıçUvi l fçö, g = 9.8 ıç/tm².]

mgıvb: M fi l R eıvııaP cıexi çö tıK meöıv h`ıZı tıK v mg`ıZıZ çöıYı DııK`m

fıi Kılç DçMöni Rb, çöıvRıx tK`çıx ej, A = $\frac{mv^2}{(R+h)}$ GUv Zıı i ga`Kıı AıfKıı ej

$$\frac{GMm}{(R+h)^2} \text{ thvıv t`q}$$

$$A_{\text{ı}} \frac{mv^2}{(R+h)} = \frac{GMm}{(R+h)^2} \quad \text{GLııb, h = 0}$$

$$\therefore v = \sqrt{\frac{GM}{R+h}}$$

$$H^{-}v\#b, g = \frac{GM}{(R+h)^2}$$

$$\therefore v = \sqrt{g(R+h)}$$

$$= \sqrt{9.8 \times (6.4 \times 10^6 + 0)} \text{ c}_u\text{exi c}_t\text{o}i \text{ L}_y \text{ u}b\text{K}_t\text{U} \text{ h Gi gvb kb}'' \text{ aiv nq}$$

$$= 7.92 \times 10^3 \text{ ug:}/\text{tm.}^2$$

7.4.4 f_7w`i DcMh

avi, GKwU Kwlg DcMhni AveZBKvj c_u_exi AvnyKMwZi AveZBKvtj i mgvb A_# 24 NbUv| c_u_exi AveZB Kvj I DcMhni AveZBKvj mgvb nl qvq c_u_exi GKRb ch#e#j#ki Kv#Q G#K me mgq w`i g#b nte| c_u_exi th `v#bi Lvov Dci t_#K G#K e#v#kvi K#j#t_ `vcb Kiv nq, GuU c_u_exi H `v#bi DciB me mgq Ae`vb Ki#e etj g#b nte| KviY c_u_exi uBR A#j#i Dci GKeri Nj#Z th mgq j#v#M, DcMhniI c_u_ex#K GKeri m#u#Y#c#v#j#Y Ki#Z H GKB mgq j#v#M| th K#j#t_ Kwlg DcMh w`i _v#K Zv#K cv#Ks K#j#c_ etj |

7.4.5 Kwlg DcMhni e`envi

Kwlg DcMhni bvbmea e`envi itqtQ| Gi mrv#h` DcMhni ch#e#j#Y m#v#i g#t# Aew`Z f_#c#o#i GjvKv m#u#t#K#e#Zvi I tUvj wfk#bi gva`tg Z_` c#v#b Kiv hvq| Avenl qvi ce#f#im c#v#b Ges Avenl qv m#s#v#s`m#Kj M#e#l#Y#q G m#Kj Kwlg DcMh L#y _i`Z#Y#e#f#v#Kv cvj b K#i _v#K| tKvb tKvb DcMhni gva`tg _i`Z#Y#e#m#v#i K Z_` m#s#Mh Kiv hvq| Avevi Av#s#gn#v#t` k#x#q teZvi I tUvj wfk#b thv#v#t#h#v#M#i GKv#k tKvb DcMh e`e#u#Z n#q _v#K| c_u_exi th tKvb t`tki Ab#v#b ZvB miv#v#i tUvj wfk#bi gva`tg t`Lv#b hvq|

Kwlg DcMhni D`PZv u#Y#e# :

c_u_exi e`v#m#v#e# I fi M a#i

24 NbUv AveZBKvtj i tKvb DcMhni f_#c#p t_#K D`PZv n#e#-

$$h = \left(\frac{GMT^2}{4\pi^2} \right)^{\frac{1}{3}} - R$$

GLv#b, M = 6 × 10²⁴ kg, R = 6.4 × 10⁶ m, T = 24 × 3600S

$$h = \left(\frac{6.7 \times 10^{-11} \text{Nm}^2\text{kg}^{-2} \times 6 \times 10^{24}\text{kg} \times (24 \times 3600\text{S})^2}{4 \times 9.87} \right)^{\frac{1}{3}} - 6.4 \times 10^6\text{m}$$

$$= 3.6 \times 10^7\text{m}$$

$$= 3.6 \times 10^4\text{km}$$

7.4.6 g#v# telM (Escape Velocity)

Avgiv Rvnb, tKvb e`#K Dc#i u#b#j#c Ki#j tmUv Av#f#K#l#P Uv#b f_#c#o#i u#d#i Av#m#e#| h#w` e`#u#t#K Ggb#v#i#e# u#b#j#c Kiv nq th, e`#u# c_u_exi Av#f#K#l#e#j#t#K Av#Z#u#g Ki#Z cv#i, Z#e# tmUv Av#i c_u_ex#Z

Avmte br/ G teMB gny³ teM/ mZivs, f₇cô nZ me³ th tetM tKvb e⁻ K w³ c Ki t j Dnv Avi c_w extZ w³ i Av³ m br Zv³ K gny³ teM et j |

avi, m f³ i i GKwU e⁻ z_w exi evB³ i f₇ t K³ nZ x⁻ i Aew⁻ Z | c_w exi fi h³ M nq, Zte e⁻ i Dci c_w exi AvKI³ e j = $\frac{GMm}{x^2}$ nte, G AvKI³ e t j i weci³ Z e⁻ i t K dx⁻ i Z j mi³ t Z th KVR nte

$$Zvi\ cwi\ gny = \frac{GMm}{x^2} dx$$

e⁻ i t K f₇ c³ ô nZ Am³ t g w³ t q th³ Z m³ ú b³ e t g w³ KVR w³ i t j

$$\begin{aligned} w' &= \int_{x=R}^{x=\infty} \frac{GMm}{x^2} dx = GMm \int_{x=R}^{x=\infty} x^{-2} dx \\ &= GMm \left[\frac{x^{-2+1}}{-2+1} \right]_{x=R}^{x=\infty} \\ &= GMm \left[\frac{x^{-1}}{-1} \right]_{x=R}^{x=\mu} \\ &= \frac{GMm}{R} \end{aligned}$$

e⁻ i t G cwi gny KVR m³ ú b³ Kivi kw³ j v f Ki t j c_w exi AvKI³ nZ gny³ crte | avi, e⁻ i t ve teM c³ ô nZ Dcti v³ cwi gny KVR Ki t Z crte | G tetM e⁻ i t M³ wZkw³ i cwi gny,

$$w'' = \frac{1}{2} mV_e^2$$

$$\text{Avevi, } w' = w''$$

$$e\text{v, } \frac{GMm}{R} = \frac{1}{2} mV_e^2$$

$$\therefore V_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2GMR}{R^2}} = \sqrt{2gR} \dots \dots \dots (7.16)$$

$$\text{GLv³ t b, } g = 9.81\text{ms}^{-2}$$

$$\text{Ges } R = 6.37 \times 10^6 \text{ m em³ t q c v B |}$$

$$V_e = 11.18 \text{ kms}^{-1}$$

AZGe tKvb e⁻ K Kgc³ t³ 11.18 kms⁻¹ tetM Dcti w³ t³ c Ki t j Zv c_w exi AvKI³ K³ w³ t q gny³ k³ b³ P³ t j hv³ te |

D`niY 2

g1/2 M0ni e`im 6600 uKtj ugvUvi Ges D³ M0n AwfKIq ZjtYi Mo gvb 3.6 ug./tm.² | GB M0n ntZ GKuU i tKtUi gvb teM ubYq Ki`b|

mgvavb:

$$GLvtb, R = \frac{6600}{2} = 3300 \text{ uK.ug.}$$

$$= 3.3 \times 10^6 \text{ ugvUvi}$$

$$g = 3.6 \text{ ug./m.}^2$$

Avgiv Rvb,

$$gvb teM v_e = \sqrt{2gR}$$

$$= \sqrt{2 \times 3.6 \times 3.3 \times 10^6}$$

$$= 48.7 \times 10^2 \text{ ug./tm.}^2$$

7.4.7 Kuig DcM0n cu`ex c0vY Kivi mgq gnvk`Pvix I RbnxbZv Abfe Ktib (An Astronaut experiences weightlessness while orbiting round the earth in an artificial satellite)

Avgiv Rvb, Kuig DcM0n cu`extK c0vY Kivi mgq tK`tegyx ej GtK uOUtK ubtq thtZ Pvq| uKsz AwfKIq ej ev Gi I Rb ZtK evav t`q, dtj gnvk`Pvix I RbnxbZv Abfe Ktib|

avi, M_r fti GKU Kuig DcM0n cu`extK tK`ti tL GKU ubv 0 Kq|c` v`vZtZ NjtQ| Zvntj Kuig DcM0nui I Rb w_r tK`tegyx ej tK ckvZ Ki te A` tK`gyx ej thvMt`Q|

$$\therefore W_r = \frac{M_r v^2}{r}$$

$$\text{ev, } \frac{v^2}{r} = \frac{W_r}{M_r} \dots \dots \dots (13.17)$$

GKRb gnvk`Pvixi I Rb w, fi m Ges Gi Dci Kuig DcM0ni c0Zuvqv ej R ntj, H gnvk`Pvix tK Kuig DcM0ni mvt` eEivKviti NjtZ c0qvRbxq ej,

$$W - R = \frac{Mv^2}{r}$$

$$\text{ev, } \frac{v^2}{r} = \frac{W}{M} - \frac{R}{M} \dots \dots \dots (13.18)$$

$$1bs \text{ mgxKi Y ntZ } \frac{v^2}{r} = \frac{W_r}{M_r} \quad 2bs \text{ mgxKi tY eimtq cIB-}$$

$$\frac{W_r}{M_r} = \frac{W}{M} - \frac{R}{M}$$

$$W \frac{W}{M} = \frac{W_r}{M_r} = g$$

$$\therefore \frac{R}{m} = \frac{W}{m} - \frac{W_r}{M_r} = g - g = 0$$

$$\therefore R = 0$$

cWZwµqv etj i gvb kb" nI qvq gnvkb" Pvi x I RbnxbZv Abyfe Ki teb|

7.4.8 tKcjvii mF (Kepler's Law)

mthP Pvi w tK Mh, uj i MwZweia j q" Kti tKcjvi wZbWU mF cWvb Ktib| G wZbWU mFB tKcjvii mF bvtg cwi wPZ|

tKcjvii mF

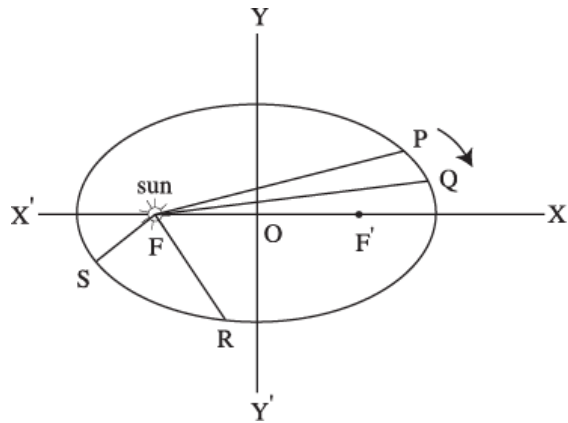
cWg mF (Ktqi mF): cWZ"K MhB mhK GKwU bvwfZ (Focus) ti tL DceFvKvi Kqct_ Ntj |

wZxq mF (tqIdtj i mF): Mh Ges mthP msthrRK ti Lv mgvb mgta mgvb tqIdj AwZµg Kti |

ZZxq mF (AveZBKvtj i mF): mthP Pvi w tK cWZwU Mhni AveZBKvtj i eMmh"t_ tK H Mhni Mo` iZji Nbdtj i mgvbZwvZK|

mFi eVLv

cWg mF: wPÎ 7.11-G PQRS GKwU DceFvKvi Kq (Orbit) | F I F'G DceFvKvi w bvwf| cWg mF Abyviti mh"G bvwf` tLvi th tKvb GKwU tZ_vKte Ges Mhmgv DceFvKvi ct_ Ntj|



wZxq mF: awi, 7.11 wPÎ F bvwfZ mh"Aew-Z| tKvb Mh hw` G Kqct_i P Ae`vb t_tK Q Ae`vb AvmtZ t mgq tbq Ges R Ae`vb t_tK S Ae`vb AvmtZ I GKB mgq t tbq| Zte, tKcjvii wZxq mF Abyviti PFQ-Gi tqIdj Ges RFS-Gi tqIdj mgvb|

wPÎ 7.11

ZZxq mF: Mh, tju DceFvKvi ct_ mhK cWwqY Kti | mwZivs wvfbæmgq mh"t_ tK th tKvb Mhni` iZj wvfbæng|

awi, th tKvb Mhni mh"tZ Mo` iZjR | H Mhni mhK Gkevi cWwqY Kitz T mgq j vtM|

∴ ZZxq mF Abyviti

$$T^2 \propto R^3 \text{ nte|}$$

A_ w mh"t_ tK R₁, R₂, R₃ Mo` iZj Aew-Z Mhni cWwqYKvj h_vµtg T₁, T₂, T₃ ntj ,

$$\frac{T_1^2}{R_1^3} = \frac{T_2^2}{R_2^3} = \frac{T_3^2}{R_3^3} = a^*eK|$$

mvi mst¶c

gnvKI¶ t¶¶: tKvb e^{-z}ev e^{-mg¶ni} Pviw ¶K hZ`i chS-Gi AvKI¶ ej AbyZ nq, tm AAj ¶K H e^{-z} gnvKI¶ t¶¶ etj |

gnvKI¶ c¶ej: gnvKI¶ t¶¶ tKvb ¶e`yZ GKK f¶i GKw e^{-z}vcb Kij, e^{-w} th AvKI¶ ej Abye K¶i, Zv¶K H t¶¶ i`i`b H ¶e`y ZxeZv ev c¶ej etj |

gnvKI¶ ¶efe: Amxg `iZj nZ GKK f¶i tKvb e^{-z} gnvKI¶ t¶¶ tKvb ¶e`yZ AvbZ th KvR KijZ nq Zv¶K H t¶¶ H ¶e`y gnvKI¶ ¶efe etj |

gv¶ tem: f;c¶ nZ me¶ath tetM tKvb e^{-z} ¶b¶¶c Kij Dnv Avi c¶ extZ w¶ti Av¶m bv Zv¶K gv¶ tem etj |

tKcjt¶i m¶: c¶g m¶ (K¶¶i m¶): c¶Z`K M¶B mh¶¶K GKw bwfZ (Focus) ti¶L Dce¶vKvi K¶c¶ Nj¶Q |

wZxq m¶ (t¶¶d¶j i m¶): M¶ Ges mh¶¶ msthvRK tiLv mgvb mg¶q mgvb t¶¶dj AwZ¶g K¶i |

ZZxq m¶ (AveZ¶vtj i m¶): mh¶¶ Pviw ¶K c¶Zw M¶ni AveZ¶Kvtj i eM¶mh¶t`¶K H M¶ni Mo`iZj Nbd¶j i mgvb¶vZK |

c¶qvRbxq mg¶KiY:

gnvKI¶ c¶ej : $E = \frac{GM}{r^2}$

gnvKI¶ ¶efe: $v = -\frac{GM}{r}$

Kw¶g DcM¶ni `i¶LK tem: $V = \left(\frac{GM}{R+h}\right)^{\frac{1}{2}}$

Kw¶g DcM¶ni `i¶LK tem I AveZ¶ Kvtj i g¶a` m¶úK¶V = $\frac{2\pi}{T} (R+h)$

Kw¶g DcM¶ni D`PZv I AveZ¶ Kvtj i g¶a` m¶úK¶h = $\left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{3}} - R$

gv¶ tem: $V_e = (2gR)^{\frac{1}{2}}$

c0k0Ei gj`vqb

K. mWk DEti c0fk Wk Pý (v) w b

1. w0tPi tKvbuU gnvKI0q c0ej`i mgxKiY?

K. $E = \frac{GM}{r^2}$ L. $E = \frac{Gr^2}{M}$ M. $E = \frac{r^2}{GM}$ N. $E = GMr^2$

2. w0tPi tKvbuU gnvKI0q w0f0ei mgxKiY?

K. $v = \frac{Wr}{M}$ L. $v = \frac{GW}{m}$ M. $v = \frac{W}{M}$ N. $v = Wrm$

3. w0tPi tKvbuU AvšR0ZK c0vZtZ gnvKI0q w0f0ei GKK?

K. Nkg^{-1} L. Jkg^{-1} M. kgN^{-1} N. $Nkg^{-2}m^2$

4. w0tPi tKvbuU Kwlg Dcm0ni t0t0 AveZ0Kvj I D`PZvi g0a` m00K0?

K. $h = \left(\frac{GM\pi^2}{4T^2}\right)^{\frac{1}{3}} - R$ L. $h = \left(\frac{GM}{4T^2\pi^2}\right)^{\frac{1}{3}} - R$
 M. $h = \left(\frac{GT^2}{4M\pi^2}\right)^{\frac{1}{3}} - R$ N. $h = \left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{3}} - R$

L. ms0f0B c0ke

1. gnvKI0q t0t0, c0ej` I w0fe Kv0K etj?
2. gnvKI0q c0ej` I w0f0ei mgxKiY I GKK wj L0j|
3. f0w`i Dcm00 ej0Z Wk et0Sb? Gi bvg f0w`i Dcm00 ivLvi A_0K?

M. iPbvj0K c0ke

1. w0DU0bi gnvKI0q m0f0U eY0v Ki`b| gnvKI0q a`et0Ki A_0ey0tq Gi GKK Ges mgxKiYwU wj L0j|
2. gnvKI0q a`eK G-wbY0qi K`v0f0U0tmi c0vZ eY0v Ki`b|
3. t`Lvb th, $g = \frac{GM}{r^2}$ thLv0b, G = gnvKI0q a`eK, M = c00exi fi Ges R = c00exi e`vma0
4. f0c00i w0f0b0e`v0b AwfKIR ZjY w0f0b0mI qvi KviY e`vL`v Ki`b| (Ab0yQ` 7.2.3)
5. AwfKI0K`0ej0Z Wk et0Sb? w0f0b0mIyg e`0t0t0 AwfKI0K`0ev fvi0K`0wbY0q Ki`b|
6. w0y0t0i Rb` gnvKI0q w0fe w0bY0q Ki`b
7. Kwlg Dcm00ni t0t0 AveZ0Kvj I D`PZvi g0a` m00K00ei Ki`b|
8. tKcjv0t0i m0f00tjv eY0v I e`vL`v Ki`b|