```
> #initialize parameters
> Digits:=16:
c:=299792458:
R:=10973731.568508:
pi:=3.1415926535897932384626433832795:
a:=137.035999139:
mu0:=(pi/(2^5*5^7)):
epsilon0:=(2500000/(pi*c^2)):
Omega:=(c^35/(2^295*3^21*pi^157*mu0^9*R^7*a^26))^(1./225):
Q:=(2^5*c^5*mu0^3/(3^3*pi*a^8*R))^(1./15):
Omega; Q;
```

$$2.007134949636316$$

$$1.019113410989319$$

```
>
>
> #2. units as q;
> m:=q^2*s/kg: c:=m/s: Q:=q: lp:=m:
> c; mP=(kg*m/s)/(m/s); Ep=(kg*m/s)*(m/s); Fp=(kg*m/s)/s;
```

$$\frac{q^2}{kg}$$

$$mP = kg$$

$$Ep = \frac{q^4}{kg}$$

$$Fp = \frac{q^2}{s}$$

```
>
> AQ=c^3/Q^3; ed=c^2*lp/Q^3; Tp=c^4/Q^3; kB=Q^5/c^3;
```

$$AQ = \frac{q^3}{kg^3}$$

$$ed = \frac{q^3\,s}{kg^3}$$

$$Tp = \frac{q^5}{kg^4}$$

$$kB = \frac{kg^3}{q}$$

```
> mu0:=Q^8/(lp*c^5): mu=mu0;
```

$$\mu = \frac{kg^6}{q^4\,s}$$

```
> sigmae:=(c^2*lp/Q^3)*c: sigma[e]=sigmae;
```

$$\sigma_e = \frac{q^5\, s}{kg^4}$$

```
> fe=sigmae^3/s; lp^2*c^10/Q^9=Q^7/mu0^2;
```

$$fe = \frac{q^{15}\, s^2}{kg^{12}}$$

$$\frac{q^{15}\, s^2}{kg^{12}} = \frac{q^{15}\, s^2}{kg^{12}}$$

```
> Rydberg=c^5*mu0^3/Q^15;
```

$$Rydberg = \frac{kg^{13}}{q^{17}\, s^3}$$

```
>
>
> R:=1/m: Q^15=c^5*mu0^3/R;
```

$$q^{15} = \frac{kg^{12}}{s^2}$$

```
> #eq(41-52)
> #Constants in terms of c, mu0, R, alpha
> hd:=(2*pi^10*mu0^3/(3^6*c^5*a^13*R^2))^(1./3):
ed:=(4*pi^5/(3^3*c^4*a^8*R))^(1./3):
ld:=(pi^22*mu0^9/(2^35*3^24*a^49*c^35*R^8))^(1./15):
td:=(pi^22*mu0^9/(2^20*3^24*a^49*c^50*R^8))^(1./15):
md:=(2^25*pi^13*mu0^6/(3^6*c^5*a^16*R^2))^(1./15):
Aq:=(2^10*pi*3^3*c^10*a^3*R/mu0^3)^(1./5):
kd:=(pi^5*mu0^3/(2*3^3*a^5*c^4*R))^(1./3):
Gd:=(pi^3*mu0/(2^20*3^6*a^11*R^2))^(1./5):
Td:=(2^10*3^3*c^15*a^3*R/(pi^4*mu0^3))^(1./5):
med:=(16*pi^10*R*mu0^3/(3^6*a^7*c^8))^(1./3):
h=hd; e=ed; l[p]=ld; t[p]=td; m[P]=md; k[B]=kd; G=Gd; T[p]=Td;
m[e]=med;
```

$$h = 0.6626069134128426\ 10^{-33}$$

$$e = 0.1602176511296910\ 10^{-18}$$

$$l_p = 0.1616036600960468\ 10^{-34}$$

$$t_p = 0.1078103573212951\ 10^{-42}$$

$$m_P = 0.2176728175801019\ 10^{-7}$$

$$k_B = 0.1379510147516053\ 10^{-22}$$

$$G = 0.6672497192291777 \ 10^{-10}$$

$$T_p = 0.1418145219320148 \ 10^{33}$$

$$m_e = 0.9109382312560075 \ 10^{-30}$$

```
>
>
>
> 4*2*pi^5*kd^4/(15*hd^3*c^3);
```
$$0.7540804678501488 \ 10^{-15}$$

```
> q^(15/2)=k^(6)/t^(1);  q^(15/2)/q^6;
rd^3=three^3*4*pi^5*mu0^3*alpha^19*R^2/(five^3*c^10);
```
$$q^{(15/2)} = \frac{k^6}{t}$$

$$q^{(3/2)}$$

$$rd^3 = \frac{4 \ three^3 \ \pi^5 \ \mu0^3 \ \alpha^{19} \ R^2}{five^3 \ c^{10}}$$

```
>
>
> #Geometrical constants
> v:=c/(2*pi*Omega^2):v;  r:=sqrt(Q/Omega):r;
> K:=Omega*v/r^2:  M:=r^4/v:  T:=2*pi*r^9/v^6:  P:=M*K :Q=P;
V:=2*pi*M*K^2: c=V; L:=(T*V/2): ld=L; A:=8*V^3/(a*P^3):Amp=A;
hd=(2*pi*L*M*V); Tkd=(A*V/pi); sigma:=3*a^2*A*L/pi^2: sigma;
fe:=sigma^3/T: fed=fe; sigma:=3*a^2*(A*V/pi)/(2*pi):   sigma;
fe:=T^2*sigma^3: fed=fe;        mu0=pi*M*V^2/(a*L*A^2);
epsilon0=(a*L*A^2/(pi*M*V^4)); ed=(A*T);  kB=pi*M*V/A;
Gd=(V**2*L/M); R=1/(4*pi*a^2*L*fe);
```
$$Q = r^2 \ \Omega$$

$$c = 2 \ \pi \ v \ \Omega^2$$

$$ld = \frac{2 \ \pi^2 \ r^9 \ \Omega^2}{v^5}$$

$$Amp = \frac{64 \ \pi^3 \ v^3 \ \Omega^3}{a \ r^6}$$

$$hd = \frac{8 \ \pi^4 \ r^{13} \ \Omega^4}{v^5}$$

$$Tkd = \frac{128 \ \pi^3 \ v^4 \ \Omega^5}{a \ r^6}$$

$$\frac{384\, a\, \pi^3\, \Omega^5\, r^3}{v^2}$$

$$fed = 28311552\, a^3\, \pi^8\, \Omega^{15}$$

$$\frac{192\, a\, \pi^2\, v^4\, \Omega^5}{r^6}$$

$$fed = 28311552\, a^3\, \pi^8\, \Omega^{15}$$

$$\mu0 = \frac{r^7\, a}{2048\, \pi^5\, \Omega^4}$$

$$\varepsilon0 = \frac{512\, \pi^3}{a\, r^7\, v^2}$$

$$ed = \frac{128\, \pi^4\, \Omega^3\, r^3}{v^3\, a}$$

$$kB = \frac{r^{10}\, a}{32\, \pi\, v^3\, \Omega}$$

$$Gd = \frac{8\, \pi^4\, \Omega^6\, r^5}{v^2}$$

$$R = \frac{v^5}{226492416\, \pi^{11}\, a^5\, r^9\, \Omega^{17}}$$

```
>
>
>
> #formulas in terms of k (mass), t (time);
> t:=(td/(2*pi)): k:=md:
> K:=Omega/(t^(2/15)*k^(1/5)):K; M:=k: md=M; T:=2*pi*t: td=T;
P:=M*K :Q=P;  V:=2*pi*M*K^2: c=V; L:=(T*V/2): ld=L;
A:=8*V^3/(a*P^3):Amp=A; hd=(2*pi*L*M*V); Tkd=(A*V/pi);
sigma:=3*a^2*A*L/pi^2: sigma; fe:=sigma^3/T: fed=fe;
sigma:=3*a^2*(A*V/pi)/(2*pi):  sigma; fe:=T^2*sigma^3: fed=fe;
mu0=pi*M*V^2/(a*L*A^2); epsilon0=(a*L*A^2/(pi*M*V^4)); ed=(A*T);
kB=pi*M*V/A;  Gd=(V**2*L/M); R=1/(4*pi*a^2*L*fe);
```

$$\frac{\Omega}{t^{(2/15)}\, k^{(1/5)}}$$

$$md = k$$

$$td = 2\, \pi\, t$$

$$Q = \frac{k^{(4/5)} \, \Omega}{t^{(2/15)}}$$

$$c = \frac{2 \, \pi \, k^{(3/5)} \, \Omega^2}{t^{(4/15)}}$$

$$ld = 2 \, \pi^2 \, t^{\left(\frac{11}{15}\right)} \, k^{(3/5)} \, \Omega^2$$

$$Amp = \frac{64 \, \pi^3 \, \Omega^3}{k^{(3/5)} \, t^{(2/5)} \, a}$$

$$hd = 8 \, \pi^4 \, t^{(7/15)} \, k^{(11/5)} \, \Omega^4$$

$$Tkd = \frac{128 \, \pi^3 \, \Omega^5}{t^{(2/3)} \, a}$$

$$384 \, a \, \pi^3 \, \Omega^5 \, t^{(1/3)}$$

$$fed = 28311552 \, a^3 \, \pi^8 \, \Omega^{15}$$

$$\frac{192 \, a \, \pi^2 \, \Omega^5}{t^{(2/3)}}$$

$$fed = 28311552 \, a^3 \, \pi^8 \, \Omega^{15}$$

$$\mu 0 = \frac{k^{(14/5)} \, a}{2048 \, \pi^5 \, \Omega^4 \, t^{(7/15)}}$$

$$\varepsilon 0 = \frac{512 \, \pi^3 \, t}{a \, k^4}$$

$$ed = \frac{128 \, \pi^4 \, \Omega^3 \, t^{(3/5)}}{k^{(3/5)} \, a}$$

$$kB = \frac{k^{(11/5)} \, t^{(2/15)} \, a}{32 \, \pi \, \Omega}$$

$$Gd = 8 \, \pi^4 \, k^{(4/5)} \, \Omega^6 \, t^{(1/5)}$$

$$R = \frac{1}{226492416 \, \pi^{11} \, a^5 \, t^{\left(\frac{11}{15}\right)} \, k^{(3/5)} \, \Omega^{17}}$$

>
>

```
>
>
>
>
>
> #Dimensionless formulas
> cd:=two*pi*Omega^2*k^(3/5)/t^(4/15):
Rd:=(1/(two^23*three^3*pi^11*a^5*Omega^17))/(t^(11/15)*k^(3/5)):
mud:=(a/(two^11*pi^5*Omega^4))*(k^(14/5)/t^(7/15)):
> cd^35/(mud^9*Rd^7);
Omega^225=(cd^35/(two^295*pi^157*three^21*a^26*mud^9*Rd^7));
```

$$two^{295}\,\pi^{157}\,\Omega^{225}\,a^{26}\,three^{21}$$

$$\Omega^{225} = \Omega^{225}$$

```
>
>
>
> l:=ld/(2*pi^2*Omega^2): v:=c/(2*pi*Omega^2): p:=Q/Omega:
r:=sqrt(p): t:=td/(2*pi): k:=md:
ax:=64*pi^3*Omega^3/(Aq*a):ax^(1/3); t^(2/15)*k^(1/5);
t^(1/6)*sqrt(r); r^2/v; k^2*t; r^17/v^8;
```

$$0.4287047104273773\ 10^{-7}$$

$$0.4287047104273770\ 10^{-7}$$

$$0.4287047104273768\ 10^{-7}$$

$$0.4287047104273771\ 10^{-7}$$

$$0.8129971343437315\ 10^{-59}$$

$$0.8129971343437332\ 10^{-59}$$

```
>
>
>
>
> cd:=two*pi*Omega^2*v:
Rd:=(1/(two^23*three^3*pi^11*a^5*Omega^17))*(v^5/p^(9/2)):
mud:=(a/(two^11*pi^5*Omega^4))*p^(7/2):
h^3=(two*pi^10*mud^3/(three^6*cd^5*a^13*Rd^2));
e^3=(two^2*pi^5/(three^3*cd^4*a^8*Rd));
kB^3=(pi^5*mud^3/(two*three^3*a^5*cd^4*Rd));
G^5=(pi^3*mud/(two^20*three^6*a^11*Rd^2));
med^3=(two^4*pi^10*Rd*mud^3/(three^6*a^7*cd^8));
```

$$h^3 = \frac{two^9\,\pi^{12}\,\Omega^{12}\,p^{(39/2)}}{v^{15}}$$

$$e^3 = \frac{two^{21}\,\pi^{12}\,\Omega^9\,p^{(9/2)}}{v^9\,a^3}$$

$$kB^3 = \frac{a^3\,p^{15}}{\pi^3\,two^{15}\,\Omega^3\,v^9}$$

$$G^5 = \frac{\pi^{20}\,two^{15}\,\Omega^{30}\,p^{(25/2)}}{v^{10}}$$

$$med^3 = \frac{p^6}{two^{60}\,\pi^{24}\,three^9\,a^9\,\Omega^{45}\,v^3}$$

```
>
>
>
>
>
>
> l:=ld/(2*pi^2*Omega^2): v:=c/(2*pi*Omega^2): p:=Q/Omega:
t:=td/(2*pi): m:=md: ax:=Aq*(a/(64*pi^3*Omega^3)):
> time=t; l^(15/11)/m^(9/11)=t; m^6/p^(15/2)=t; p^(9/2)/v^6=t;
(ax*l)^3=t; l^(6/5)/p^(9/10)=t; 1/(ax^2*p^(3/2))=t;
```

$$time = 0.1715855128418762\ 10^{-43}$$

$$0.1715855128418759\ 10^{-43} = 0.1715855128418762\ 10^{-43}$$

$$0.1715855128418776\ 10^{-43} = 0.1715855128418762\ 10^{-43}$$

$$0.1715855128418768\ 10^{-43} = 0.1715855128418762\ 10^{-43}$$

$$0.1715855128418743\ 10^{-43} = 0.1715855128418762\ 10^{-43}$$

$$0.1715855128418761\ 10^{-43} = 0.1715855128418762\ 10^{-43}$$

$$0.1715855128418774\ 10^{-43} = 0.1715855128418762\ 10^{-43}$$

```
>
>
>
> hd:=two^3*pi^4*Omega^4*t^(7/15)*k^(11/5):
ed:=two^7*pi^4*Omega^3*t^(3/5)/(k^(3/5)*a):
cd:=two*pi*Omega^2*k^(3/5)/t^(4/15):
Rd:=(1/(two^23*three^3*pi^11*a^5*Omega^17))/(t^(11/15)*k^(3/5)):
mud:=(a/(two^11*pi^5*Omega^4))*(k^(14/5)/t^(7/15)):
a=two*hd/(mud*ed^2*cd);
```

$$a = a$$

```
> rd^3=three^3*two^2*pi^5*mud^3*a^19*Rd^2/(five^3*cd^10);
```

$$rd3 = \frac{a^{12} k^{(6/5)}}{three^3 \, two^{87} \, \pi^{42} \, \Omega^{66} \, t^{(1/5)} \, five^3}$$

> `(a^4/(three*five*two^29*pi^14*Omega^22))^2;`

$$\frac{a^8}{three^2 \, five^2 \, two^{58} \, \pi^{28} \, \Omega^{44}}$$

>
>
>
>
>
>