```
> with(student):
> Digits:=4;
```

$$Digits := 4$$

```
> meter:100*cm;
```

$$100\ cm$$

```
> r[w]:=G*mw/c^2;
```

$$r_w := \frac{G\ mw}{c^2}$$

```
> meter:=100*cm;
```

$$meter := 100\ centimeter$$

```
>
> mw*c*r[w]/.4336929462e-34;
```

$$.9913\ 10^{23}\ \frac{grm\ centimeter \left(.5950\ 10^{9}\ \dfrac{grm\ second^2\ 6^{(1/3)} \left(\dfrac{centimeter^8\ \pi^2\ \rho^2\ \lambda^2}{second^6\ grm^2} \right)^{(1/3)}}{\pi\ centimeter^3\ \rho\ \lambda} \right)_w}{second}$$

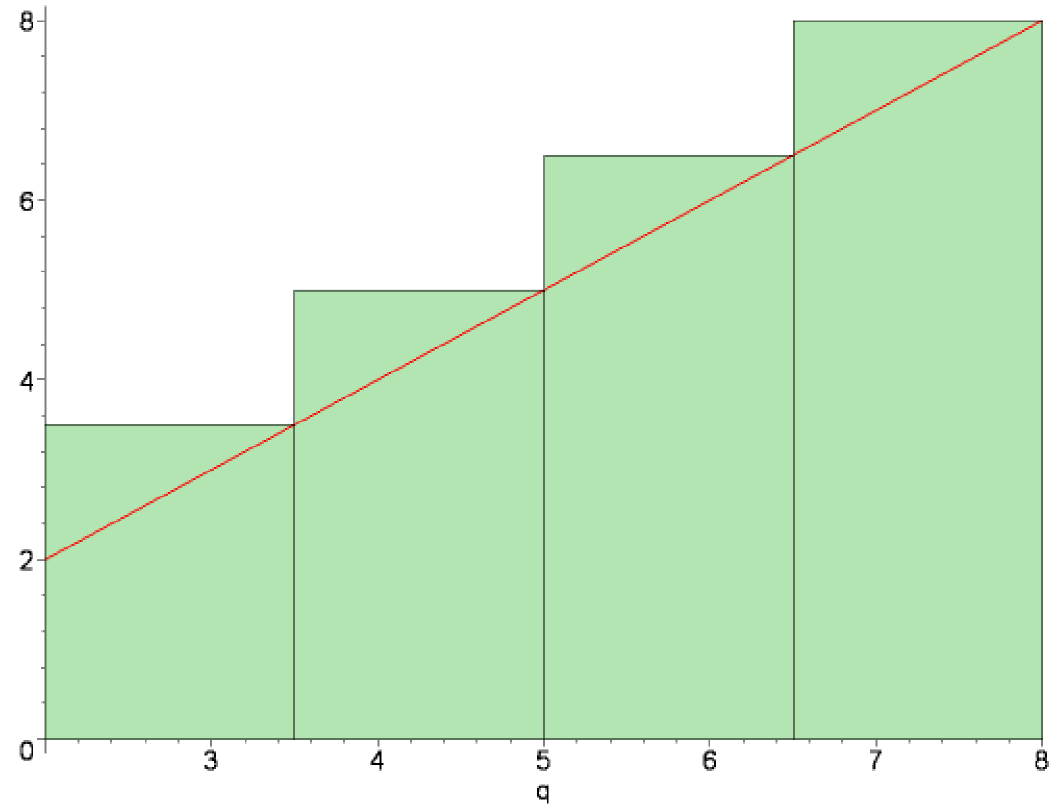
```
> hbar;
```

$$.1055\ 10^{-26}\ \frac{centimeter^2\ grm}{second}$$

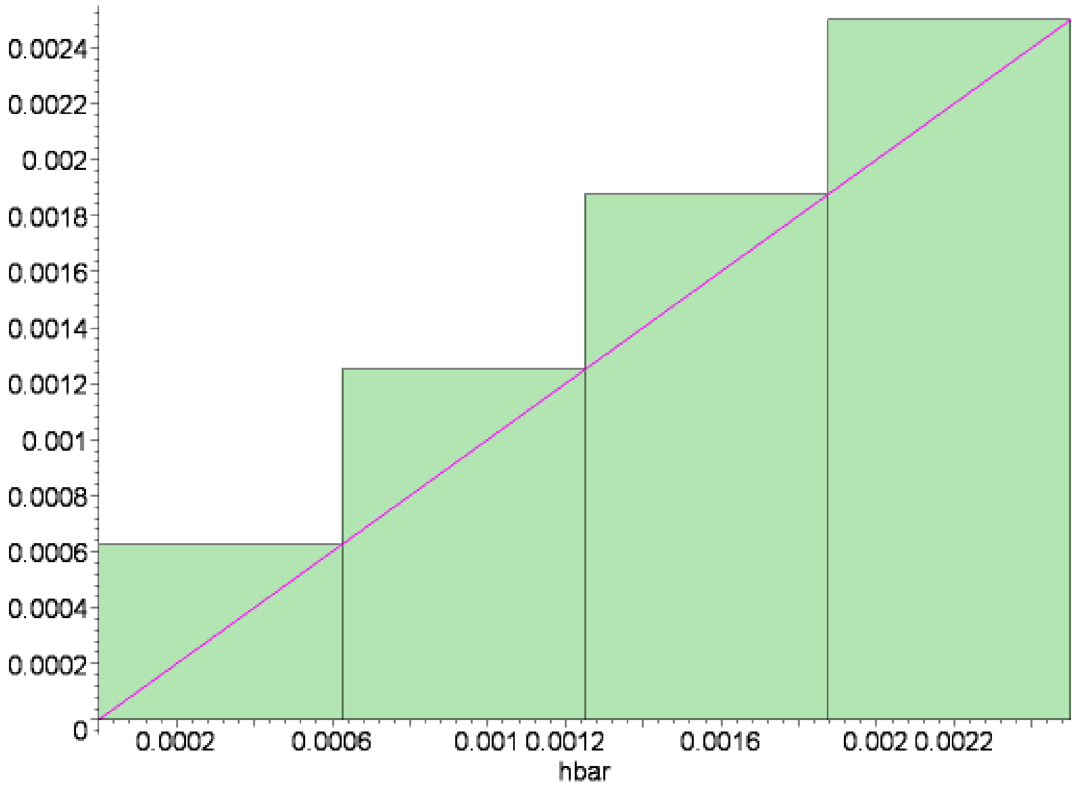
```
> rightbox(3*x^2/(8*pi*G)),x=2..8,color=red;
```

$$\mathrm{rightbox}\left(\frac{3}{8}\ \frac{x^2}{\pi\ G} \right),\ x = 2\ ..\ 8,\ color = red$$

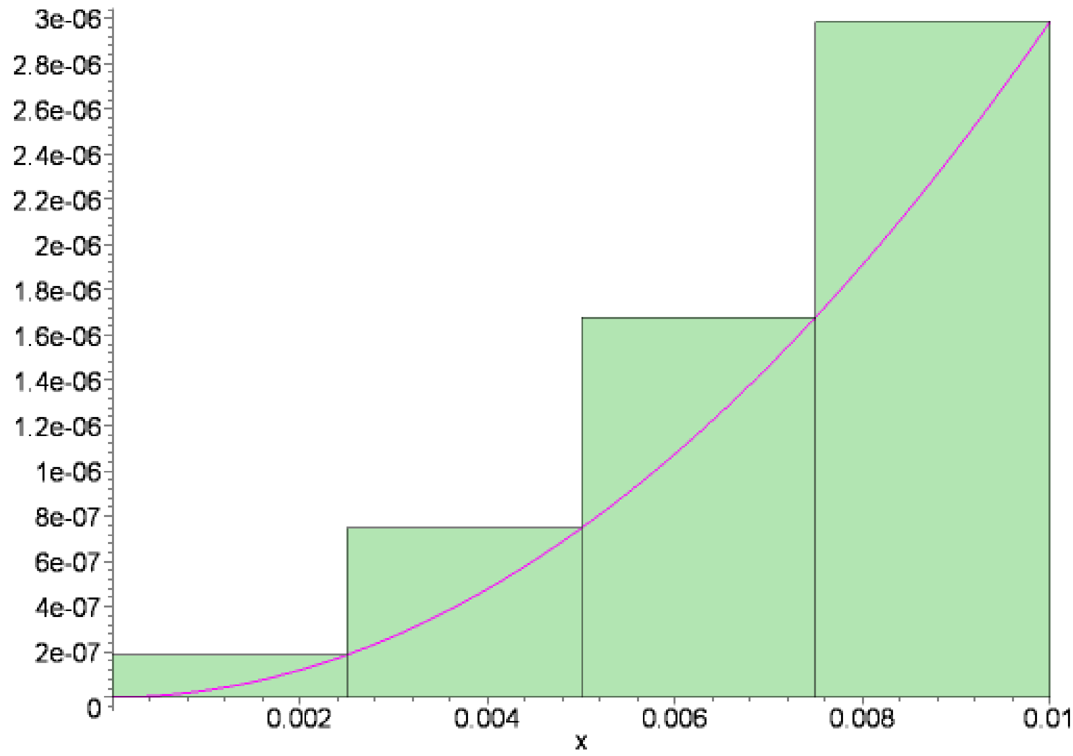
```
> q:=3*x^2/(8*pi*G):
> rightbox(q,q=2..8,color=RED);
```




```
> rightbox(hbar,hbar=(10^(-23))..sin(20.^(-2)),color=MAGENTA);
```




```
> rightbox(3*x^2/(8*3.14*4),x=0..10^(-2),color=MAGENTA);
```




```
> x:=hubbleconst:
```

Dobijanje Plankove konstante iz bozonskog w dejstva

```
> criticaldensity := 3*x^2/(8*pi*G):
> coeff(q,x);
```

$$6\,a - y^2 + 1$$

```
> 3/8*hubbleconst^2/(pi*G);
```

$$.2304\ 10^{-29}\ \frac{grm}{centimeter^3}$$

```
> #criticaldensity
>
>
>
>
>
>
> hubbleconst := 70*hubnum*km/second/(mega*parsec);
```

$$hubbleconst := .1135\ 10^{-17}\ \frac{1}{second}$$

```
> H[B]:=(18*10^9*year)^(-1);Rg[sv]:=(H[B]/c)^(-1);M[sv]:=c^2*Rg[s]
  /G;rho[sv]:=3*M[sv]/(4*pi*Rg[s]^3);
```

$$H_B := .1761\ 10^{-17}\ \frac{1}{second}$$

$$Rg_{sv} := .1703\ 10^{29}\ centimeter$$

$$M_{sv} := .1347\ 10^{29} \frac{Rg_s\ grm}{centimeter}$$

$$\rho_{sv} := .3215\ 10^{28} \frac{grm}{centimeter\ Rg_s^{\ 2}}$$

```
> rho[sv]:=3*M[sv]/(4*pi*Rg[s]^3);
```

$$\rho_{sv} := .3215\ 10^{28} \frac{grm}{centimeter\ Rg_s^{\ 2}}$$

```
> rho[sv]*Rg[s]^3*4*pi/3;
```

$$.1347\ 10^{29} \frac{Rg_s\ grm}{centimeter}$$

```
> Rg[s]:=.1702895113e27*meter;
```

$$Rg_s := .1703\ 10^{29}\ centimeter$$

```
> M[sv]  := .1346853257e28*Rg[sv]*kg/meter;
```

$$M_{sv} := .2294\ 10^{57}\ grm$$

```
> .2425e38*year*c*kg/meter;
```

$$.2294\ 10^{57}\ grm$$

```
> H[B];
```

$$.1761\ 10^{-17} \frac{1}{second}$$

```
> (H[B]^2-(8/3)*pi*G*rho[sv])*Rg[sv]^2*M[sv];
```

$$-.2064\ 10^{78} \frac{centimeter^2\ grm}{second^2}$$

```
> (H[B]^2-(8/3)*pi*G*rho[sv])*Rg[sv]^2*M[sv]/c^2;
```

$$-.2297\ 10^{57}\ grm$$

Energija Svemira

```
> M[sv]*c^2;
```

$$.2062\ 10^{78} \frac{centimeter^2\ grm}{second^2}$$

```
> (H[B]^2-(8/3)*pi*G*rho[sv])*Rg[sv]^2*M[sv]/(-.3895367658e81*mete
  r*kg/(second^2));
```

$$.5298\ 10^{-8}\ centimeter$$

Odmah iznad - Borov radijus iz Fridmanove jednacine. Isto kao u Mahcadu.

```
> R4 :=
```

$$\mathrm{simplify}\left(\frac{.1210491340\ 10^{45}\left(\frac{.3099314210\ 10^{-35}}{second^2} - \frac{.1797510357\ 10^{18}\ meter^2}{second^2\ Rg_s^{\ 2}}\right) meter\ Rg_s\ kg}{H_b^{\ 2}\ second^2}\right)$$

$$R4 := -.6390\ 10^{42} \frac{centimeter^2\ grm}{second^4\ {H_b}^2}$$

> R5 := factor(R4)

$$R5 := -.6390\ 10^{42} \frac{centimeter^2\ grm}{second^4\ {H_b}^2}$$

```
> Rg[sv];
```

$$.1703\ 10^{29}\ centimeter$$

```
> R2  := simplify(299792458/H[B]*meter/second);
```

$$R2 := .1703\ 10^{29}\ centimeter$$

> R3 := factor(R2)

$$R3 := .1703\ 10^{29}\ centimeter$$

$$> R0 := \text{simplify}\left(\frac{.1210491340\ 10^{45}\left(\frac{1}{324000000000000000000\ yr^2} - \frac{.1797510357\ 10^{18}\ meter^2}{second^2\ {Rg_s}^2}\right) meter\ Rg_s\ kg}{{H_b}^2\ second^2}\right)$$

$$R0 := .5089\ 10^{39} \frac{(.1250\ 10^{19}\ second^2 - 2511.\ yr^2)\ centimeter^2\ grm}{yr^2\ second^4\ {H_b}^2}$$

> R1 := expand(R0)

$$R1 := .6361\ 10^{57} \frac{centimeter^2\ grm}{yr^2\ second^2\ {H_b}^2} - .1278\ 10^{43} \frac{centimeter^2\ grm}{second^4\ {H_b}^2}$$

Sledi jedan cetvorokomponentni niz podeljen koeficijentom srazmernosti i to daje jedan elektrovolt. Sada cu topodeliti masom elektrona, pronaci koeficijent i izracunati masu elektrona.

```
> ev;
```

$$.1602\ 10^{-11} \frac{centimeter^2\ grm}{second^2}$$

```
> G*M[sv]/c^2;
```

$$.1704\ 10^{29}\ centimeter$$

Vidimo kako smo dobili masu elektrona. Mirabilis 4 u ovom slucaju pravljen je tako da se racuna iz onoga sto se dobija.Ne vracam se na prvobitni mirabilis. Sada cu iz dobijenog Mirabilis 4 izracunati masu svemira

```
> M[sv];
```

$$.2294\ 10^{57}\ grm$$

Iz Mirabilis za masu elektrona dobio sam masu Svemira pomocu koeficijenta srazmernosti.A potom, jos slozenijom procedurom, Borov radijus.

```
> .6671e-10*matrix([[mw], [1/18000000000*1/year], [c],
  [bohr]])*meter^3/(matrix([[.1434e-24*kg], [.1761e-17*1/second],
  [299792458*meter/second], [bohr]])*kg*second^2);
```

$$.6671\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2}$$

```
matrix([[mw], [H[B]], [c], [bohr]])/%?;
> matrix([[me*c^2*alpha^2/2], [G], [milkyway],
  [alpha],[ev],[rbohr],[re],[Rg[s]],[M[sv]],[me],[mw]]);
>
```

$$\begin{bmatrix} \frac{1}{2}\,me\,c^2\,\alpha^2 \\ G \\ milkyway \\ \alpha \\ ev \\ rbohr \\ re \\ Rg_s \\ M_{sv} \\ me \\ mw \end{bmatrix}$$

$$> R11 := linalg_{transpose}\left(\text{array}\left(1..11, 1..1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (2,1) = G, (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right)\right)$$

$$R11 := \left[.2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2}, .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2}, .2200\ 10^{45}\ grm, .007292, .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2}, .5292\ 10^{-8}\ centimeter, .2814\ 10^{-12}\ centimeter, .1703\ 10^{29}\ centimeter, .2294\ 10^{57}\ grm, .9111\ 10^{-27}\ grm, .1434\ 10^{-21}\ grm\right]$$

```
> ((matrix([[me*c^2*alpha^2/2], [G], [mmilkyway],
  [alpha],[ev],[rbohr],[re],[Rg[s]],[M[sv]],[me],[mw]])));
```

$$\left[\begin{array}{c} .2177\ 10^{-10}\,\frac{centimeter^2\,grm}{second^2} \\ .6673\ 10^{-7}\,\frac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\,grm \\ .007292 \\ .1602\ 10^{-11}\,\frac{centimeter^2\,grm}{second^2} \\ .5292\ 10^{-8}\,centimeter \\ .2814\ 10^{-12}\,centimeter \\ .1703\ 10^{29}\,centimeter \\ .2294\ 10^{57}\,grm \\ .9111\ 10^{-27}\,grm \\ .1434\ 10^{-21}\,grm \end{array}\right]$$

```
> R6 = linalg[transpose](array(1 .. 11,1 .. 1,[(6, 1) =
  .5301e-10*meter, (7, 1) = .2819e-14*meter, (4, 1) = .7292e-2,
  (5, 1) = .1602e-18*meter^2*kg/second^2, (1, 1) =
  .2177e-17*meter^2*kg/second^2, (10, 1) = .9111e-30*kg, (2, 1) =
  .6673e-10*meter^3/kg/second^2, (8, 1) = .1702895113e27*meter,
  (11, 1) = .1434e-24*kg, (3, 1) = .2200e42*kg, (9, 1) =
  .2294e54*kg]));
```

$$L^2\, i\, \gamma^{\mu}\, D_{\mu} - .00003149\, L^2\, i^2\, \gamma^{\mu}\, Y_L\, B_{\mu} + .6415\ 10^{-8}\, I\, L^2\, i^2\, \gamma^{\mu}\, Y_L\, B_{\mu} + .1547\, L^2\, i^2\, \gamma^{\mu}\, \overline{\tau}\, \overline{W}$$
$$+ L\, i^2\, \gamma^{\mu}\, \overline{R}\, \gamma^{\langle\, \mu\, \rangle}\, R\, D_{\mu} - .00003149\, L\, i^3\, \gamma^{\mu}\, \overline{R}\, \gamma^{\langle\, \mu\, \rangle}\, R\, Y_R\, B_{\mu}$$
$$+ .6415\ 10^{-8}\, I\, L\, i^3\, \gamma^{\mu}\, \overline{R}\, \gamma^{\langle\, \mu\, \rangle}\, R\, Y_R\, B_{\mu} - \frac{1}{4}\, \overline{W}_{\mu,\nu}\, \overline{W}^{\langle\, \mu,\nu\, \rangle} - \frac{1}{4}\, B_{\mu,\nu}\, B^{\langle\, \mu,\nu\, \rangle} + {D_{\mu}}^2$$
$$- .00006298\, D_{\mu}\, Y\, B_{\mu} + .1283\ 10^{-7}\, I\, D_{\mu}\, Y\, B_{\mu} + .3094\, D_{\mu}\, i\, \overline{\tau}\, \overline{W}_{\mu}\, \Phi + .9916\ 10^{-9}\, Y^2\, {B_{\mu}}^2$$
$$- .4040\ 10^{-12}\, I\, Y^2\, {B_{\mu}}^2 - .9744\ 10^{-5}\, Y\, B_{\mu}\, i\, \overline{\tau}\, \overline{W}_{\mu}\, \Phi + .1985\ 10^{-8}\, I\, Y\, B_{\mu}\, i\, \overline{\tau}\, \overline{W}_{\mu}\, \Phi$$
$$+ .02393\, i^2\, \overline{\tau}^2\, {\overline{W}_{\mu}}^2\, \Phi^2 - V_{\Phi} - g_e\, \overline{L}\, \Phi\, R - g_e\, \Phi\, \overline{R}\, L =$$
$$\left[.2177\ 10^{-10}\,\frac{centimeter^2\,grm}{second^2},\ .6673\ 10^{-7}\,\frac{centimeter^3}{grm\ second^2},\ .2200\ 10^{45}\,grm,\ .007292,\right.$$
$$.1602\ 10^{-11}\,\frac{centimeter^2\,grm}{second^2},\ .5301\ 10^{-8}\,centimeter,\ .2819\ 10^{-12}\,centimeter,$$
$$\left. .1703\ 10^{29}\,centimeter,\ .2294\ 10^{57}\,grm,\ .9111\ 10^{-27}\,grm,\ .1434\ 10^{-21}\,grm \right]$$

$$> R9 := \mathrm{evalm}\left(R6 = \mathrm{array}\left(1..1, 1..11, \left[(1,5) = \frac{.1602\ 10^{-18}\,meter^2\,kg}{second^2},\ (1,11) = .1434\ 10^{-24}\,kg,\right.\right.\right.$$

$(1,3) = .2200\ 10^{42}\ kg,\ (1,4) = .007292,\ (1,6) = .5301\ 10^{-10}\ meter,$

$(1,1) = \frac{.2177\ 10^{-17}\ meter^2\ kg}{second^2},\ (1,2) = \frac{.6673\ 10^{-10}\ meter^3}{kg\ second^2},\ (1,9) = .2294\ 10^{54}\ kg,$

$(1,7) = .2819\ 10^{-14}\ meter,\ (1,10) = .9111\ 10^{-30}\ kg,\ (1,8) = .1702895113\ 10^{27}\ meter\ ]\,])\,)$

$$R9 := L^2\, i\, \gamma^\mu\, D_\mu - .00003149\, L^2\, i^2\, \gamma^\mu\, Y_L\, B_\mu + .6415\ 10^{-8}\, I\, L^2\, i^2\, \gamma^\mu\, Y_L\, B_\mu + .1547\, L^2\, i^2\, \gamma^\mu\, \bar{\tau}\, \overline{W}$$
$$+ L\, i^2\, \gamma^\mu\, \bar{R}\, \gamma^{\langle \mu \rangle}\, R\, D_\mu - .00003149\, L\, i^3\, \gamma^\mu\, \bar{R}\, \gamma^{\langle \mu \rangle}\, R\, Y_R\, B_\mu$$
$$+ .6415\ 10^{-8}\, I\, L\, i^3\, \gamma^\mu\, \bar{R}\, \gamma^{\langle \mu \rangle}\, R\, Y_R\, B_\mu - \frac{1}{4}\, \overline{W}_{\mu,\nu}\, \overline{W}^{\langle \mu,\nu \rangle} - \frac{1}{4}\, B_{\mu,\nu}\, B^{\langle \mu,\nu \rangle} + {D_\mu}^2$$
$$- .00006298\, D_\mu\, Y\, B_\mu + .1283\ 10^{-7}\, I\, D_\mu\, Y\, B_\mu + .3094\, D_\mu\, i\, \bar{\tau}\, \overline{W}_\mu\, \Phi + .9916\ 10^{-9}\, Y^2\, {B_\mu}^2$$
$$- .4040\ 10^{-12}\, I\, Y^2\, {B_\mu}^2 - .9744\ 10^{-5}\, Y\, B_\mu\, i\, \bar{\tau}\, \overline{W}_\mu\, \Phi + .1985\ 10^{-8}\, I\, Y\, B_\mu\, i\, \bar{\tau}\, \overline{W}_\mu\, \Phi$$
$$+ .02393\, i^2\, \bar{\tau}^2\, {\overline{W}_\mu}^2\, \Phi^2 - V_\Phi - g_e\, \bar{L}\, \Phi\, R - g_e\, \Phi\, \bar{R}\, L =$$

$$\left[.2177\ 10^{-10}\, \frac{centimeter^2\ grm}{second^2},\ .6673\ 10^{-7}\, \frac{centimeter^3}{grm\ second^2},\ .2200\ 10^{45}\ grm,\ .007292,\right.$$
$$.1602\ 10^{-11}\, \frac{centimeter^2\ grm}{second^2},\ .5301\ 10^{-8}\ centimeter,\ .2819\ 10^{-12}\ centimeter,$$
$$\left. .1703\ 10^{29}\ centimeter,\ .2294\ 10^{57}\ grm,\ .9111\ 10^{-27}\ grm,\ .1434\ 10^{-21}\ grm \right]$$

```
> linalg[transpose](array(1 .. 11,1 .. 1,[(6, 1) =
.5301e-10*meter, (7, 1) = .2819e-14*meter, (4, 1) = .7292e-2,
(5, 1) = .1602e-18*meter^2*kg/second^2, (1, 1) =
.2177e-17*meter^2*kg/second^2, (10, 1) = .9111e-30*kg, (2, 1) =
.6673e-10*meter^3/kg/second^2, (8, 1) = .1702895113e27*meter,
(11, 1) = .1434e-24*kg, (3, 1) = .2200e42*kg, (9, 1) =
.2294e54*kg]))/(.1886e11*matrix([[.2177e-17*meter^2*kg/(second^2
), .6673e-10*meter^3/(kg*second^2), .2200e42*kg, .7292e-2,
.1602e-18*meter^2*kg/(second^2), .5301e-10*meter,
.2819e-14*meter, .1702895113e27*meter, .2294e54*kg,
.9111e-30*kg, .1434e-24*kg]])/meter);
```

$$.5302\ 10^{-8}\ centimeter$$

```
> rbohr:=linalg[transpose](array(1 .. 11,1 .. 1,[(6, 1) =
.5301e-10*meter, (7, 1) = .2819e-14*meter, (4, 1) = .7292e-2,
(5, 1) = .1602e-18*meter^2*kg/second^2, (1, 1) =
.2177e-17*meter^2*kg/second^2, (10, 1) = .9111e-30*kg, (2, 1) =
.6673e-10*meter^3/kg/second^2, (8, 1) = .1702895113e27*meter,
(11, 1) = .1434e-24*kg, (3, 1) = .2200e42*kg, (9, 1) =
.2294e54*kg]))/(.1886e11*matrix([[.2177e-17*meter^2*kg/(second^2
), .6673e-10*meter^3/(kg*second^2), .2200e42*kg, .7292e-2,
.1602e-18*meter^2*kg/(second^2), .5301e-10*meter,
```

```
.2819e-14*meter, .1702895113e27*meter, .2294e54*kg,
.9111e-30*kg, .1434e-24*kg]])/meter);
```

$$rbohr := .5302\ 10^{-8}\ centimeter$$

```
> [(6, 1) = .5301e-10*meter, (7, 1) = .2819e-14*meter, (4, 1) =
.7292e-2, (5, 1) = .1602e-18*meter^2*kg/second^2, (1, 1) =
.2177e-17*meter^2*kg/second^2, (10, 1) = .9111e-30*kg, (2, 1) =
.6673e-10*meter^3/kg/second^2, (8, 1) = .1702895113e27*meter,
(11, 1) = .1434e-24*kg, (3, 1) = .2200e42*kg, (9, 1) =
.2294e54*kg]/(.1886e11*matrix([[.2177e-17*meter^2*kg/(second^2),
.6673e-10*meter^3/(kg*second^2), .2200e42*kg, .7292e-2,
.1602e-18*meter^2*kg/(second^2), .5301e-10*meter,
.2819e-14*meter, .1702895113e27*meter, .2294e54*kg,
.9111e-30*kg, .1434e-24*kg]])/meter)=rbohr;
```

$$.5302\ 10^{-8} \Bigg(\Bigg[(6, 1) = .5301\ 10^{-8}\ centimeter, (7, 1) = .2819\ 10^{-12}\ centimeter, (4, 1) = .007292, (5, 1) = .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2}, (1, 1) = .2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2}, (10, 1) = .9111\ 10^{-27}\ grm, (2, 1) = .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2}, (8, 1) = .1703\ 10^{29}\ centimeter, (11, 1) = .1434\ 10^{-21}\ grm, (3, 1) = .2200\ 10^{45}\ grm, (9, 1) = .2294\ 10^{57}\ grm \Bigg]\ centimeter \Bigg) \Big/ \Bigg[.2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2}, .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2}, .2200\ 10^{45}\ grm, .007292, .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2}, .5301\ 10^{-8}\ centimeter, .2819\ 10^{-12}\ centimeter, .1703\ 10^{29}\ centimeter, .2294\ 10^{57}\ grm, .9111\ 10^{-27}\ grm, .1434\ 10^{-21}\ grm \Bigg] = .5302\ 10^{-8}\ centimeter$$

```
> R3 := linalg[transpose](array(1 .. 11,1 .. 1,[(6, 1) = rbohr,
(3, 1) = mmilkyway, (8, 1) = Rg[s], (4, 1) = alpha, (11, 1) =
mw, (5, 1) = ev, (1, 1) = 1/2*me*c^2*alpha^2, (2, 1) = G, (10,
1) = me, (9, 1) = M[sv], (7, 1) =
re]))&*((((matrix([[me*c^2*alpha^2/2], [G], [mmilkyway],
[alpha],[ev],[rbohr],[re],[Rg[s]],[M[sv]],[me],[mw]])))));
```

$$R3 :=$$

$$\Bigg[.2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2}, .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2}, .2200\ 10^{45}\ grm, .007292,$$

$$.1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2},\ .5302\ 10^{-8}\ centimeter,\ .2814\ 10^{-12}\ centimeter,$$

$$.1703\ 10^{29}\ centimeter,\ .2294\ 10^{57}\ grm,\ .9111\ 10^{-27}\ grm,\ .1434\ 10^{-21}\ grm\ \Big]\ \&*$$

$$\left[\begin{array}{c} .2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2} \\ .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\ grm \\ .007292 \\ .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2} \\ .5302\ 10^{-8}\ centimeter \\ .2814\ 10^{-12}\ centimeter \\ .1703\ 10^{29}\ centimeter \\ .2294\ 10^{57}\ grm \\ .9111\ 10^{-27}\ grm \\ .1434\ 10^{-21}\ grm \end{array}\right]$$

```
> R3;
```

$$\Big[\ .2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2},\ .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2},\ .2200\ 10^{45}\ grm,\ .007292,$$

$$.1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2},\ .5302\ 10^{-8}\ centimeter,\ .2814\ 10^{-12}\ centimeter,$$

$$.1703\ 10^{29}\ centimeter,\ .2294\ 10^{57}\ grm,\ .9111\ 10^{-27}\ grm,\ .1434\ 10^{-21}\ grm\ \Big]\ \&*$$

$$\begin{bmatrix} .2177\ 10^{-10}\ \dfrac{centimeter^2\ grm}{second^2} \\ .6673\ 10^{-7}\ \dfrac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\ grm \\ .007292 \\ .1602\ 10^{-11}\ \dfrac{centimeter^2\ grm}{second^2} \\ .5302\ 10^{-8}\ centimeter \\ .2814\ 10^{-12}\ centimeter \\ .1703\ 10^{29}\ centimeter \\ .2294\ 10^{57}\ grm \\ .9111\ 10^{-27}\ grm \\ .1434\ 10^{-21}\ grm \end{bmatrix}$$

```
> linalg[transpose](array(1 .. 11,1 .. 1,[(6, 1) = rbohr, (3, 1) =
mmilkyway, (8, 1) = Rg[s], (4, 1) = alpha, (11, 1) = mw, (5, 1)
= ev, (1, 1) = 1/2*me*c^2*alpha^2, (2, 1) = G, (10, 1) = me, (9,
1) = M[sv], (7, 1) = re]))&*((((matrix([[me*c^2*alpha^2/2], [G],
[mmilkyway],
[alpha],[ev],[rbohr],[re],[Rg[s]],[M[sv]],[me],[mw]])))))/(`&*`(
matrix([[1/2*me*c^2*alpha^2, G, mmilkyway, alpha, ev, rbohr, re,
Rg[s], M[sv], me, mw]]),matrix([[1/2*me*c^2*alpha^2], [G],
[mmilkyway], [alpha], [ev], [rbohr], [re], [Rg[s]], [M[sv]],
[me], [mw]]))/rbohr);
```

$$.5302\ 10^{-8}\ centimeter$$

$$> R26 := \mathrm{evalm}\left(\mathrm{array}\left(1\,..\,1, 1\,..\,11, \left[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\right]\right)\ \&*\ 1\ /\ \mathrm{array}\left(1\,..\,11, 1\,..\,1, \left[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\right]\right)\right)$$

```
Error, (in linalg[inverse]) expecting a square matrix
```

$$> R25 := \mathrm{evalm}\left(\mathrm{array}\left(1\,..\,1, 1\,..\,11, \left[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re,\right.\right.\right.$$

$$(1,8)=Rg_s\Big]\Big)\ \&*\ \text{array}\Big(1..11,1..1,\Big[(6,1)=rbohr,(3,1)=mmilkyway,(8,1)=Rg_s,$$

$$(4,1)=\alpha,(11,1)=mw,(5,1)=ev,(1,1)=\frac{1\,me\,c^2\,\alpha^2}{2},(2,1)=G,(10,1)=me,$$

$$(9,1)=M_{sv},(7,1)=re\Big]\Big)\Big)$$

$R25$:=

$$\left[.4765\ 10^{-21}\ \frac{centimeter^4\ grm^2}{second^4}+.4453\ 10^{-14}\ \frac{centimeter^6}{grm^2\ second^4}+.5262\ 10^{113}\ grm^2+.00005317\right.$$

$$\left.+.2900\ 10^{57}\ centimeter^2\right]$$

$$> R24 := \text{evalm}\Big(\text{array}\Big(1..1,1..11,\Big[(1,2)=G,(1,9)=M_{sv},(1,3)=mmilkyway,(1,10)=me,$$

$$(1,1)=\frac{1\,me\,c^2\,\alpha^2}{2},(1,4)=\alpha,(1,11)=mw,(1,5)=ev,(1,6)=rbohr,(1,7)=re,$$

$$(1,8)=Rg_s\Big]\Big)\ \&*\ \text{array}\Big(1..11,1..1,\Big[(6,1)=rbohr,(3,1)=mmilkyway,(8,1)=Rg_s,$$

$$(4,1)=\alpha,(11,1)=mw,(5,1)=ev,(1,1)=\frac{1\,me\,c^2\,\alpha^2}{2},(2,1)=G,(10,1)=me,$$

$$(9,1)=M_{sv},(7,1)=re\Big]\Big)^2\Big)$$

```
Error, (in linalg[multiply]) non matching dimensions for vector/matrix product
> map((R3,diff(r3,me)));
Error, wrong number (or type) of parameters in function diff
```

$$> R0 := \text{conjugate}\Big(\Big(\text{array}\Big(1..1,1..11,\Big[(1,5)=ev,(1,11)=mw,(1,3)=mmilkyway,$$

$$(1,4)=\alpha,(1,6)=rbohr,(1,1)=\frac{1\,me\,c^2\,\alpha^2}{2},(1,2)=G,(1,9)=\frac{c^2\,Rg_s}{G},(1,7)=re,$$

$$(1,10)=me,(1,8)=Rg_s\Big]\Big)\ \&*\ \text{array}\Big(1..11,1..1,\Big[(6,1)=rbohr,(7,1)=re,(4,1)=\alpha,$$

$$(5,1)=ev,(1,1)=\frac{1\,me\,c^2\,\alpha^2}{2},(10,1)=me,(2,1)=G,(8,1)=Rg_s,(11,1)=mw,$$

$$(3,1)=mmilkyway,(9,1)=\frac{c^2\,Rg_s}{G}\Big]\Big)\Big)(0)\Big)$$

$$R0 := \text{conjugate}\Bigg(\Bigg(\left[.2177\ 10^{-10}\,\frac{centimeter^2\,grm}{second^2},\ .6673\ 10^{-7}\,\frac{centimeter^3}{grm\,second^2},\ .2200\ 10^{45}\,grm,\ .007292,\ .1602\ 10^{-11}\,\frac{centimeter^2\,grm}{second^2},\ .5302\ 10^{-8}\,centimeter,\ .2814\ 10^{-12}\,centimeter,\ .1703\ 10^{29}\,centimeter,\ .2294\ 10^{57}\,grm,\ .9111\ 10^{-27}\,grm,\ .1434\ 10^{-21}\,grm\right]\ \&*$$

$$\left[\begin{array}{c} .2177\ 10^{-10}\,\frac{centimeter^2\,grm}{second^2} \\ .6673\ 10^{-7}\,\frac{centimeter^3}{grm\,second^2} \\ .2200\ 10^{45}\,grm \\ .007292 \\ .1602\ 10^{-11}\,\frac{centimeter^2\,grm}{second^2} \\ .5302\ 10^{-8}\,centimeter \\ .2814\ 10^{-12}\,centimeter \\ .1703\ 10^{29}\,centimeter \\ .2294\ 10^{57}\,grm \\ .9111\ 10^{-27}\,grm \\ .1434\ 10^{-21}\,grm \end{array}\right]\Bigg)(0)\Bigg)$$

> $R1 := \text{evalf}\Big(\text{conjugate}\Big(\Big(\text{array}\Big(1\,..\,1,\ 1\,..\,11,\ \Big[(1, 5) = ev,\ (1, 11) = mw,\ (1, 3) = mmilkyway,$
$(1, 4) = \alpha,\ (1, 6) = rbohr,\ (1, 1) = \frac{1\ me\ c^2\ \alpha^2}{2},\ (1, 2) = G,\ (1, 9) = \frac{c^2\ Rg_s}{G},\ (1, 7) = re,$

$(1, 10) = me, (1, 8) = Rg_s \Big]\Big]\Big) \&* \operatorname{array}\Big(1 .. 11, 1 .. 1, \Big[(6, 1) = rbohr, (7, 1) = re, (4, 1) = \alpha,$

$(5, 1) = ev, (1, 1) = \frac{1\, me\, c^2\, \alpha^2}{2}, (10, 1) = me, (2, 1) = G, (8, 1) = Rg_s, (11, 1) = mw,$

$(3, 1) = mmilkyway, (9, 1) = \frac{c^2\, Rg_s}{G}\Big]\Big)\Big)(0)\Big), 5\Big)$

$R1 := \operatorname{conjugate}\Bigg(\Bigg($

$\Big[.21771\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2}, .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2}, .2200\ 10^{45}\ grm, .007292,$

$.1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2}, .5302\ 10^{-8}\ centimeter, .2814\ 10^{-12}\ centimeter,$

$.1703\ 10^{29}\ centimeter, .22937\ 10^{57}\ grm, .9111\ 10^{-27}\ grm, .1434\ 10^{-21}\ grm\Big] \&*$

$$\left(\begin{bmatrix} .21771\ 10^{-10} \dfrac{centimeter^2\ grm}{second^2} \\ .6673\ 10^{-7} \dfrac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\ grm \\ .007292 \\ .1602\ 10^{-11} \dfrac{centimeter^2\ grm}{second^2} \\ .5302\ 10^{-8}\ centimeter \\ .2814\ 10^{-12}\ centimeter \\ .1703\ 10^{29}\ centimeter \\ .22937\ 10^{57}\ grm \\ .9111\ 10^{-27}\ grm \\ .1434\ 10^{-21}\ grm \end{bmatrix}\right)(0)$$

> $R16 := \text{evalf}\Big(\Big(\text{array}\Big(1..1, 1..11, \Big[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\Big]\Big)\ \&*\ \text{array}\Big(1..11, 1..1, \Big[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\Big]\Big)\Big)(0), 5\Big)$

$R16 := \Big($

$$\left[.21771\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2},\ .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2},\ .2200\ 10^{45}\ grm,\ .007292,\ .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2},\ .5302\ 10^{-8}\ centimeter,\ .2814\ 10^{-12}\ centimeter,\ .1703\ 10^{29}\ centimeter,\ .2294\ 10^{57}\ grm,\ .9111\ 10^{-27}\ grm,\ .1434\ 10^{-21}\ grm\right] \&*$$

$$\left(\begin{bmatrix} .21771\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2} \\ .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\ grm \\ .007292 \\ .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2} \\ .5302\ 10^{-8}\ centimeter \\ .2814\ 10^{-12}\ centimeter \\ .1703\ 10^{29}\ centimeter \\ .2294\ 10^{57}\ grm \\ .9111\ 10^{-27}\ grm \\ .1434\ 10^{-21}\ grm \end{bmatrix}\right)(0)$$

> $$R15 := \Im\Big(\big(\mathrm{array}\big(1..1, 1..11, [(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s]\big)\ \&*\ \mathrm{array}\big(1..11, 1..1, [(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re]\big)\big)(0)\Big)$$

$$R15 := \Im\Bigg(\Bigg(\left[.2177\ 10^{-10} \frac{centimeter^2\ grm}{second^2}, .6673\ 10^{-7} \frac{centimeter^3}{grm\ second^2}, .2200\ 10^{45}\ grm, .007292, .1602\ 10^{-11} \frac{centimeter^2\ grm}{second^2}, .5302\ 10^{-8}\ centimeter, .2814\ 10^{-12}\ centimeter, .1703\ 10^{29}\ centimeter, .2294\ 10^{57}\ grm, .9111\ 10^{-27}\ grm, .1434\ 10^{-21}\ grm \right] \&^*$$

$$\left[\begin{matrix} .2177\ 10^{-10} \frac{centimeter^2\ grm}{second^2} \\ .6673\ 10^{-7} \frac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\ grm \\ .007292 \\ .1602\ 10^{-11} \frac{centimeter^2\ grm}{second^2} \\ .5302\ 10^{-8}\ centimeter \\ .2814\ 10^{-12}\ centimeter \\ .1703\ 10^{29}\ centimeter \\ .2294\ 10^{57}\ grm \\ .9111\ 10^{-27}\ grm \\ .1434\ 10^{-21}\ grm \end{matrix}\right]\Bigg)(0)\Bigg)$$

> $R19 := \text{evalc}\Big(\Im\Big(\Big(\text{array}\Big(1 .. 1, 1 .. 11, \Big[(1, 2) = G, (1, 9) = M_{sv}, (1, 3) = mmilkyway, (1, 10) = me, (1, 1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (1, 4) = \alpha, (1, 11) = mw, (1, 5) = ev, (1, 6) = rbohr,$

$(1,7) = re, (1,8) = Rg_s \Big]\Big) \&* \operatorname{array}\Big(1..11, 1..1, \Big[(6,1) = rbohr, (3,1) = mmilkyway,$

$(8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\, me\, c^2\, \alpha^2}{2}, (2,1) = G,$

$(10,1) = me, (9,1) = M_{sv}, (7,1) = re \Big]\Big)\Big)(0)\Big)\Big)$

$$R19 := 0$$

```
> R17 := conjugate(Im(`&*`(array(1 .. 1,1 .. 11,[(1, 2) = G, (1,
9) = M[sv], (1, 3) = mmilkyway, (1, 10) = me, (1, 1) =
1/2*me*c^2*alpha^2, (1, 4) = alpha, (1, 11) = mw, (1, 5) = ev,
(1, 6) = rbohr, (1, 7) = re, (1, 8) = Rg[s]]),array(1 .. 11,1 ..
1,[(6, 1) = rbohr, (3, 1) = mmilkyway, (8, 1) = Rg[s], (4, 1) =
alpha, (11, 1) = mw, (5, 1) = ev, (1, 1) = 1/2*me*c^2*alpha^2,
(2, 1) = G, (10, 1) = me, (9, 1) = M[sv], (7, 1) = re]))(0)));
```

$R17 := \Im\Big(\Big($

$\Big[.2177\ 10^{-10} \frac{centimeter^2\ grm}{second^2}, .6673\ 10^{-7} \frac{centimeter^3}{grm\ second^2}, .2200\ 10^{45}\ grm, .007292,$

$.1602\ 10^{-11} \frac{centimeter^2\ grm}{second^2}, .5302\ 10^{-8}\ centimeter, .2814\ 10^{-12}\ centimeter,$

$.1703\ 10^{29}\ centimeter, .2294\ 10^{57}\ grm, .9111\ 10^{-27}\ grm, .1434\ 10^{-21}\ grm \Big] \&*$

$$\left[\begin{array}{c} .2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2} \\ .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\ grm \\ .007292 \\ .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2} \\ .5302\ 10^{-8}\ centimeter \\ .2814\ 10^{-12}\ centimeter \\ .1703\ 10^{29}\ centimeter \\ .2294\ 10^{57}\ grm \\ .9111\ 10^{-27}\ grm \\ .1434\ 10^{-21}\ grm \end{array}\right]\Bigg)(0)\Bigg)$$

$$> R20 := \mathrm{sqrt}\Bigg(\Re\Bigg(\Im\Bigg(\Bigg(\mathrm{array}\Bigg(1..1, 1..11, \Bigg[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\Bigg]\Bigg)\ \&*\ \mathrm{array}\Bigg(1..11, 1..1, \Bigg[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\Bigg]\Bigg)\Bigg)(0)\Bigg)\Bigg)^2 + \Im\Bigg(\Im\Bigg(\Bigg(\mathrm{array}\Bigg(1..1, 1..11, \Bigg[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\Bigg]\Bigg)\ \&*\ \mathrm{array}\Bigg(1..11, 1..1, \Bigg[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\Bigg]\Bigg)\Bigg)(0)\Bigg)\Bigg)^2\Bigg)$$

$$R20 := \mathrm{sqrt}\left(\Im\left(\left(\left[.2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2},\ .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2},\ .2200\ 10^{45}\ grm,\ .007292,\ .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2},\ .5302\ 10^{-8}\ centimeter,\ .2814\ 10^{-12}\ centimeter,\ .1703\ 10^{29}\ centimeter,\ .2294\ 10^{57}\ grm,\ .9111\ 10^{-27}\ grm,\ .1434\ 10^{-21}\ grm\right] \&* \left(\left[\begin{array}{c} .2177\ 10^{-10}\ \frac{centimeter^2\ grm}{second^2} \\ .6673\ 10^{-7}\ \frac{centimeter^3}{grm\ second^2} \\ .2200\ 10^{45}\ grm \\ .007292 \\ .1602\ 10^{-11}\ \frac{centimeter^2\ grm}{second^2} \\ .5302\ 10^{-8}\ centimeter \\ .2814\ 10^{-12}\ centimeter \\ .1703\ 10^{29}\ centimeter \\ .2294\ 10^{57}\ grm \\ .9111\ 10^{-27}\ grm \\ .1434\ 10^{-21}\ grm \end{array}\right]\right)(0)\right)^2\right)\right)$$

```
> [9,1];
```

$$[9, 1]$$

$$> R21 := \operatorname{sqrt}\left(\Re\left(\left(\Im\left(\left(\operatorname{array}\left(1..1, 1..11, \left[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\right]\right)\ \&*\ \operatorname{array}\left(1..11, 1..1, \left[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\right]\right)\right)(0)\right)^2\right)^{\left(\frac{1}{2}\right)}\right)^2 + \Im\left(\left(\Im\left(\left(\operatorname{array}\left(1..1, 1..11, \left[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\right]\right)\ \&*\ \operatorname{array}\left(1..11, 1..1, \left[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\right]\right)\right)(0)\right)^2\right)^{\left(\frac{1}{2}\right)}\right)^2\right)$$

$$R21 := \operatorname{sqrt}\left(\Im\left(\left(\left[.2177\ 10^{-17}\ \frac{meter^2\ kg}{second^2}, .6673\ 10^{-10}\ \frac{meter^3}{kg\ second^2}, .2200\ 10^{42}\ kg, .007292, .1602\ 10^{-18}\ \frac{meter^2\ kg}{second^2}, .5301\ 10^{-10}\ meter, .2819\ 10^{-14}\ meter, .1702895113\ 10^{27}\ meter,\right.\right.\right.\right.$$

$$\left[.2294\ 10^{54}\ kg\ , .9111\ 10^{-30}\ kg\ , .1434\ 10^{-24}\ kg \right] \&* \left[\begin{array}{c} .2177\ 10^{-17} \frac{meter^2\ kg}{second^2} \\ .6673\ 10^{-10} \frac{meter^3}{kg\ second^2} \\ .2200\ 10^{42}\ kg \\ .007292 \\ .1602\ 10^{-18} \frac{meter^2\ kg}{second^2} \\ .5301\ 10^{-10}\ meter \\ .2819\ 10^{-14}\ meter \\ .1702895113\ 10^{27}\ meter \\ .2294\ 10^{54}\ kg \\ .9111\ 10^{-30}\ kg \\ .1434\ 10^{-24}\ kg \end{array} \right]) (0)) ^2)$$

> $R22 := \text{evalc}\left(\left(\Im\left(\left(\text{array}\left(1 .. 1, 1 .. 11, \left[(1,2) = G, (1,9) = M_{sv}, (1,3) = mmilkyway, (1,10) = me, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (1,4) = \alpha, (1,11) = mw, (1,5) = ev, (1,6) = rbohr, (1,7) = re, (1,8) = Rg_s\right]\right)\right) \&* \text{array}\left(1 .. 11, 1 .. 1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (2,1) = G, (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right)\right)(0)\right)^2\right)^{\left(\frac{1}{2}\right)}\right)$

$$R22 := 0$$

> $R18 := \text{convert}\left(\text{evalc}\left(\Im\left(\left(\text{array}\left(1 .. 1, 1 .. 11, \left[(1,2) = G, (1,9) = M_{sv}, (1,3) = mmilkyway, (1,10) = me, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (1,4) = \alpha, (1,11) = mw, (1,5) = ev, (1,6) = rbohr, (1,7) = re, (1,8) = Rg_s\right]\right)\right) \&* \text{array}\left(1 .. 11, 1 .. 1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (2,1) = G, (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right)\right)(0)\right)\right), polar\right)$

$$R18 := \text{polar}(0, 0)$$

>

>

> $R14 := \Re\left(\left(\text{array}\left(1..1, 1..11, \left[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\, me\, c^2\, \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\right]\right) \&^* \text{array}\left(1..11, 1..1, \left[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\, me\, c^2\, \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\right]\right)\right)(0)\right)$

$R14 := \Re\Bigg(\Bigg($

$\left[.2177\ 10^{-17} \frac{meter^2\, kg}{second^2}, .6673\ 10^{-10} \frac{meter^3}{kg\, second^2}, .2200\ 10^{42}\ kg, .007292,\right.$

$.1602\ 10^{-18} \frac{meter^2\, kg}{second^2}, .5301\ 10^{-10}\ meter, .2819\ 10^{-14}\ meter, .1702895113\ 10^{27}\ meter,$

$$.2294\ 10^{54}\ kg\ ,\ .9111\ 10^{-30}\ kg\ ,\ .1434\ 10^{-24}\ kg \Big] \&* \left[\left[\begin{array}{c} .2177\ 10^{-17}\ \frac{meter^2\ kg}{second^2} \\ .6673\ 10^{-10}\ \frac{meter^3}{kg\ second^2} \\ .2200\ 10^{42}\ kg \\ .007292 \\ .1602\ 10^{-18}\ \frac{meter^2\ kg}{second^2} \\ .5301\ 10^{-10}\ meter \\ .2819\ 10^{-14}\ meter \\ .1702895113\ 10^{27}\ meter \\ .2294\ 10^{54}\ kg \\ .9111\ 10^{-30}\ kg \\ .1434\ 10^{-24}\ kg \end{array}\right]\right](0)\Bigg)$$

```
> R13 := evalm(`&*`(array(1 .. 1,1 .. 11,[(1, 2) = G, (1, 9) =
M[sv], (1, 3) = mmilkyway, (1, 10) = me, (1, 1) =
1/2*me*c^2*alpha^2, (1, 4) = alpha, (1, 11) = mw, (1, 5) = ev,
(1, 6) = rbohr, (1, 7) = re, (1, 8) = Rg[s]]),array(1 .. 11,1 ..
1,[(6, 1) = rbohr, (3, 1) = mmilkyway, (8, 1) = Rg[s], (4, 1) =
alpha, (11, 1) = mw, (5, 1) = ev, (1, 1) = 1/2*me*c^2*alpha^2,
(2, 1) = G, (10, 1) = me, (9, 1) = M[sv], (7, 1) = re])));
```

$$R13 := \left[.4765\ 10^{-35}\ \frac{meter^4\ kg^2}{second^4} + .4453\ 10^{-20}\ \frac{meter^6}{kg^2\ second^4} + .5262\ 10^{107}\ kg^2 + .00005317 + .2900\ 10^{53}\ meter^2\right]$$

$$> R12 := \text{evalm}\left(\text{array}\left(1\,..\,1, 1\,..\,11, \left[(1,2)=G, (1,9)=M_{sv}, (1,3)=mmilkyway, (1,10)=me, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (1,4)=\alpha, (1,11)=mw, (1,5)=ev, (1,6)=rbohr, (1,7)=re, (1,8)=Rg_s\right]\right) \&*\ 1\ /\ \text{array}\left(1\,..\,11, 1\,..\,1, \left[(6,1)=rbohr, (3,1)=mmilkyway, (8,1)=Rg_s, (4,1)=\alpha, (11,1)=mw, (5,1)=ev, (1,1)=\frac{1\ me\ c^2\ \alpha^2}{2}, (2,1)=G, (10,1)=me, (9,1)=M_{sv}, (7,1)=re\right]\right)\right)$$

```
Error, (in linalg[inverse]) expecting a square matrix
```

$$> R4 := [\,linalg_{rowdim}(R3),\ linalg_{coldim}(R3)\,]$$

```
Error, (in linalg[rowdim]) expecting a matrix
```

```
> R3/((matrix([[me*c^2*alpha^2/2], [G], [mmilkyway],
[alpha],[ev],[rbohr],[re],[Rg[s]],[M[sv]],[me],[mw]])));
```

$$.1703\ 10^{27} \frac{meter}{\left[\begin{array}{c} .2177\ 10^{-17} \dfrac{meter^2\ kg}{second^2} \\ .6673\ 10^{-10} \dfrac{meter^3}{kg\ second^2} \\ .2200\ 10^{42}\ kg \\ .007292 \\ .1602\ 10^{-18} \dfrac{meter^2\ kg}{second^2} \\ .5301\ 10^{-10}\ meter \\ .2819\ 10^{-14}\ meter \\ .1702895113\ 10^{27}\ meter \\ .2294\ 10^{54}\ kg \\ .9111\ 10^{-30}\ kg \\ .1434\ 10^{-24}\ kg \end{array}\right]}$$

> $R7 := \mathrm{evalm}\left(R3\ \&*\ \mathrm{array}\left(1..11, 1..1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1}{2} me\ c^2\ \alpha^2, (2,1) = G, (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right)\right)$

$$R7 := .1703\ 10^{27} \left(meter\ \&* \left[\begin{array}{c} .2177\ 10^{-17} \dfrac{meter^2\ kg}{second^2} \\ .6673\ 10^{-10} \dfrac{meter^3}{kg\ second^2} \\ .2200\ 10^{42}\ kg \\ .007292 \\ .1602\ 10^{-18} \dfrac{meter^2\ kg}{second^2} \\ .5301\ 10^{-10}\ meter \\ .2819\ 10^{-14}\ meter \\ .1702895113\ 10^{27}\ meter \\ .2294\ 10^{54}\ kg \\ .9111\ 10^{-30}\ kg \\ .1434\ 10^{-24}\ kg \end{array}\right]\right)$$

> $R7 := \left[\frac{1}{4} me^2\ c^4\ \alpha^4 + G^2 + mmilkyway^2 + \alpha^2 + ev^2 + rbohr^2 + re^2 + {Rg_s}^2 + {M_{sv}}^2 + me^2 + mw^2\right]$

$R7 :=$

$$\left[.4766\ 10^{-35}\ \frac{meter^4\ kg^2}{second^4} + .4453\ 10^{-20}\ \frac{meter^6}{kg^2\ second^4} + .5262\ 10^{107}\ kg^2 + .00005317 + .2900\ 10^{53}\ meter^2\right]$$

```
> (1/4*me^2*c^4*alpha^4+G^2+mmilkyway^2+alpha^2+ev^2+rbohr^2+re^2+
Rg[s]^2+M[sv]^2+me^2+mw^2)/(1/4*me^2*c^4*alpha^4+G^2+mmilkyway^2
+alpha^2+ev^2+rbohr^2+re^2+Rg[s]^2+M[sv]^2+me^2+mw^2)/(1/4*me^2*
c^4*alpha^4+G^2+mmilkyway^2+alpha^2+ev^2+rbohr^2+re^2+Rg[s]^2+M[
sv]^2+me^2+mw^2)/(1/((1/4*me^2*c^4*alpha^4+G^2+mmilkyway^2+alpha
^2+ev^2+rbohr^2+re^2+Rg[s]^2+M[sv]^2+me^2+mw^2)*alpha^2));
```

$$.00005317$$

$$> R8 := \text{simplify}\left(\frac{1}{\left(\frac{1\ me^2\ c^4\ \alpha^4}{4} + G^2 + mmilkyway^2 + \alpha^2 + ev^2 + rbohr^2 + re^2 + {Rg_s}^2 + {M_{sv}}^2 + me^2 + mw^2\right) rbohr^3}\right)$$

$$R8 := .3357\ 10^{70}\ kg^2\ second^4 \Big/ ((2383.\ meter^4\ kg^4 + .2227\ 10^{19}\ meter^6 + .2631\ 10^{146}\ kg^4\ second^4 + .2659\ 10^{35}\ kg^2\ second^4 + .1450\ 10^{92}\ meter^2\ kg^2\ second^4)\ meter^3)$$

```
> R7/(R7/alpha);
```

$$.007292$$

$$> R5 := \text{evalm}\left(R3\ \text{array}\left(1..11, 1..1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (2,1) = G, (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right)\right)$$

$$R5 := \begin{bmatrix} .3707\ 10^{9}\ \dfrac{meter^3\ kg}{second^2} \\ .1136\ 10^{17}\ \dfrac{meter^4}{kg\ second^2} \\ .3747\ 10^{68}\ meter\ kg \\ .1242\ 10^{25}\ meter \\ .2728\ 10^{8}\ \dfrac{meter^3\ kg}{second^2} \\ .9028\ 10^{16}\ meter^2 \\ .4801\ 10^{12}\ meter^2 \\ .2900\ 10^{53}\ meter^2 \\ .3907\ 10^{80}\ meter\ kg \\ .0001552\ meter\ kg \\ 24.42\ meter\ kg \end{bmatrix}$$

> $R2 := \left[linalg_{rowdim}\left(\text{array}\left(1..11, 1..1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (2,1) = G, (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right)\right), linalg_{coldim}\left(\text{array}\left(1..11, 1..1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (2,1) = G, (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right)\right)\right]$

$$R2 := [11, 1]$$

```
> matrix([[1/2*me*c^2*alpha^2], [G(me)], [mmilkyway], [alpha],
[ev], [rbohr], [re], [Rg[s]], [M[sv]], [me],
[mw]])((matrix([[1/2*me(rbohr/alpha)*c(rbohr/alpha)^2*alpha(rboh
r/alpha)^2], [G(me)(rbohr/alpha)], [mmilkyway(rbohr/alpha)],
[alpha(rbohr/alpha)], [ev(rbohr/alpha)], [rbohr(rbohr/alpha)],
[re(rbohr/alpha)], [Rg[s](rbohr/alpha)], [M[sv](rbohr/alpha)],
[me(rbohr/alpha)], [mw(rbohr/alpha)]])));
```

$$\Big[.2177\ 10^{-17}\ \text{meter}\Big($$

$$\left[.2177\ 10^{-17}\ \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2} \right]$$

$$\left[.6673\ 10^{-10}\ \frac{\text{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\text{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \text{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2} \right.$$

$$\Bigg]$$

$$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\Big)^2\ \mathrm{kg}\Big($$

$$\left[.2177\ 10^{-17}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\mathrm{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \mathrm{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}\right.$$

$$\Bigg]$$

$$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\Big)\ \Big/\ \mathrm{second}\Big($$

$$\left[.2177\ 10^{-17} \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10} \frac{\mathrm{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \mathrm{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}\right.$$

$$\left.\vphantom{\frac{a}{b}}\right]$$

$$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18} \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$\left.\left.[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\right)^2\right]$$

$$\left[.6673\ 10^{-10}\ \mathrm{meter}(.9111\ 10^{-30}\ kg)\right(\Bigg.$$

$$\left[.2177\ 10^{-17} \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10} \frac{\mathrm{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \mathrm{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}\right.$$

$$\left.\vphantom{\frac{a}{b}}\right]$$

$$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18} \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$[.2819\ 10^{-14}\ \text{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.1702895113\ 10^{27}\ \text{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.2294\ 10^{54}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.9111\ 10^{-30}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.1434\ 10^{-24}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]\Big)^3 \Big/ \Big(\text{kg}(.9111\ 10^{-30}\ \mathit{kg})\Big($

$$\left[.2177\ 10^{-17}\ \frac{\text{meter}(.7270\ 10^{-8}\ \mathit{meter})^2\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})}{\text{second}(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\text{meter}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^3}{\text{kg}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})\ \text{second}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^2}\right.$$

$$\Bigg]$$

$[.2200\ 10^{42}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.007292]$

$$\left[.1602\ 10^{-18}\ \frac{\text{meter}(.7270\ 10^{-8}\ \mathit{meter})^2\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})}{\text{second}(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$[.5301\ 10^{-10}\ \text{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.2819\ 10^{-14}\ \text{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.1702895113\ 10^{27}\ \text{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.2294\ 10^{54}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.9111\ 10^{-30}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.1434\ 10^{-24}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]\Big)\ \text{second}(.9111\ 10^{-30}\ \mathit{kg})\Big($

$$\left[.2177\ 10^{-17}\ \frac{\text{meter}(.7270\ 10^{-8}\ \mathit{meter})^2\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})}{\text{second}(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\text{meter}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^3}{\text{kg}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})\ \text{second}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^2}\right.$$

$$\Bigg]$$

$[.2200\ 10^{42}\ \text{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.007292]$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$

$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$

$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$

$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$

$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$

$[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\Big)^2\Big)\Big]$

$$\left[.2200\ 10^{42}\ \mathrm{kg}\right($$

$$\left[.2177\ 10^{-17}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\mathrm{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \mathrm{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}\right.$$

$$\Big]$$

$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$

$[.007292]$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$

$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$

$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$

$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$

$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$

$[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\Big)\Big]$

$[.007292]$

$$\left[.1602\ 10^{-18}\ \mathrm{meter}\right($$

$$\left[.2177\ 10^{-17}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})^2\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})}{\mathrm{second}(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\mathrm{meter}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^3}{\mathrm{kg}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})\ \mathrm{second}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.007292]$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})^2\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})}{\mathrm{second}(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})]\Big)^2\ \mathrm{kg}\Big($

$$\left[.2177\ 10^{-17}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})^2\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})}{\mathrm{second}(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\mathrm{meter}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^3}{\mathrm{kg}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})\ \mathrm{second}(.9111\ 10^{-30}\ \mathit{kg})(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.007292]$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})^2\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})}{\mathrm{second}(.7270\ 10^{-8}\ \mathit{meter})^2}\right]$$

$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ \mathit{meter})]$

$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ \mathit{meter})]$

$$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$\left.[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\right) \Big/ \mathrm{second}\Big($$

$$\left[.2177\ 10^{-17}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\mathrm{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \mathrm{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$\left.\left.[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\right)^2\right]$$

$$\left[.5301\ 10^{-10}\ \mathrm{meter}\Big(\right.$$

$$\left[.2177\ 10^{-17}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\mathrm{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \mathrm{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\Big)\Big]$$

$$\Big[.2819\ 10^{-14}\ \mathrm{meter}\Big($$

$$\left[.2177\ 10^{-17}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\Bigg[.6673\ 10^{-10}\ \frac{\mathrm{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \mathrm{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}$$

$$\Bigg]$$

$$[.2200\ 10^{42}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18}\ \frac{\mathrm{meter}(.7270\ 10^{-8}\ meter)^2\ \mathrm{kg}(.7270\ 10^{-8}\ meter)}{\mathrm{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$[.5301\ 10^{-10}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2819\ 10^{-14}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.1702895113\ 10^{27}\ \mathrm{meter}(.7270\ 10^{-8}\ meter)]$$

$$[.2294\ 10^{54}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.9111\ 10^{-30}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.1434\ 10^{-24}\ \mathrm{kg}(.7270\ 10^{-8}\ meter)]\Big)\Big]$$

$$\Big[.1702895113\ 10^{27}\ \mathrm{meter}\Big($$

$$\left[.2177\ 10^{-17} \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2} \right]$$

$$\left[.6673\ 10^{-10} \frac{\text{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\text{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \text{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2} \right]$$

$[.2200\ 10^{42}\ \text{kg}(.7270\ 10^{-8}\ meter)]$

$[.007292]$

$$\left[.1602\ 10^{-18} \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2} \right]$$

$[.5301\ 10^{-10}\ \text{meter}(.7270\ 10^{-8}\ meter)]$

$[.2819\ 10^{-14}\ \text{meter}(.7270\ 10^{-8}\ meter)]$

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$[.2294\ 10^{54}\ \text{kg}(.7270\ 10^{-8}\ meter)]$

$[.9111\ 10^{-30}\ \text{kg}(.7270\ 10^{-8}\ meter)]$

$[.1434\ 10^{-24}\ \text{kg}(.7270\ 10^{-8}\ meter)]\Big)\Big]$

$$\Big[.2294\ 10^{54}\ \text{kg}\Big($$

$$\left[.2177\ 10^{-17} \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2} \right]$$

$$\left[.6673\ 10^{-10} \frac{\text{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\text{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \text{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2} \right]$$

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$$\left[.1602\ 10^{-18} \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2} \right]$$

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$[.9111\ 10^{-30}\ \text{kg}(.7270\ 10^{-8}\ meter)]$

$[.1434\ 10^{-24}\ \text{kg}(.7270\ 10^{-8}\ meter)]\Big)\Big]$

$$\left[.9111\ 10^{-30}\ \text{kg}\left(\right.\right.$$

$$\left[.2177\ 10^{-17}\ \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10}\ \frac{\text{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\text{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \text{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2}\right]$$

$\Big]$

$[.2200\ 10^{42}\ \text{kg}(.7270\ 10^{-8}\ meter)]$

$[.007292]$

$$\left[.1602\ 10^{-18}\ \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$[.5301\ 10^{-10}\ \text{meter}(.7270\ 10^{-8}\ meter)]$

$[.2819\ 10^{-14}\ \text{meter}(.7270\ 10^{-8}\ meter)]$

$[.1702895113\ 10^{27}\ \text{meter}(.7270\ 10^{-8}\ meter)]$

$[.2294\ 10^{54}\ \text{kg}(.7270\ 10^{-8}\ meter)]$

$[.9111\ 10^{-30}\ \text{kg}(.7270\ 10^{-8}\ meter)]$

$[.1434\ 10^{-24}\ \text{kg}(.7270\ 10^{-8}\ meter)]\Big)\Big]$

$$\left[.1434\ 10^{-24}\ \text{kg}\left(\right.\right.$$

$$\left[.2177\ 10^{-17}\ \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2}\right]$$

$$\left[.6673\ 10^{-10} \frac{\text{meter}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^3}{\text{kg}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)\ \text{second}(.9111\ 10^{-30}\ kg)(.7270\ 10^{-8}\ meter)^2} \right]$$

$$[.2200\ 10^{42}\ \text{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.007292]$$

$$\left[.1602\ 10^{-18} \frac{\text{meter}(.7270\ 10^{-8}\ meter)^2\ \text{kg}(.7270\ 10^{-8}\ meter)}{\text{second}(.7270\ 10^{-8}\ meter)^2} \right]$$

$$[.5301\ 10^{-10}\ \text{meter}(.7270\ 10^{-8}\ meter)]$$

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$$[.2294\ 10^{54}\ \text{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.9111\ 10^{-30}\ \text{kg}(.7270\ 10^{-8}\ meter)]$$

$$[.1434\ 10^{-24}\ \text{kg}(.7270\ 10^{-8}\ meter)] \Big) \Big]$$

> $R1 := \text{evalm}\left(\text{array}\left(1..11, 1..1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\ me\ c^2\ \alpha^2}{2}, (2,1) = \text{G}(me), (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right) rbohr / \alpha\right)$

$$R1 := \begin{bmatrix} .1583\ 10^{-25} \frac{meter^3\ kg}{second^2} \\ .4851\ 10^{-18} \frac{meter\ \text{meter}(.9111\ 10^{-30}\ kg)^3}{\text{kg}(.9111\ 10^{-30}\ kg)\ \text{second}(.9111\ 10^{-30}\ kg)^2} \\ .1599\ 10^{34}\ meter\ kg \\ .5301\ 10^{-10}\ meter \\ .1165\ 10^{-26} \frac{meter^3\ kg}{second^2} \\ .3854\ 10^{-18}\ meter^2 \\ .2049\ 10^{-22}\ meter^2 \\ .1238\ 10^{19}\ meter^2 \\ .1668\ 10^{46}\ meter\ kg \\ .6624\ 10^{-38}\ meter\ kg \\ .1043\ 10^{-32}\ meter\ kg \end{bmatrix}$$

> $R0 := \text{evalm}\left(\text{array}\left(1..11, 1..1, \left[(6,1) = rbohr, (3,1) = mmilkyway, (8,1) = Rg_s, (4,1) = \alpha, (11,1) = mw, (5,1) = ev, (1,1) = \frac{1\, me\, c^2\, \alpha^2}{2}, (2,1) = \mathrm{G}(me), (10,1) = me, (9,1) = M_{sv}, (7,1) = re\right]\right) rbohr\right)$

$$R0 := \begin{bmatrix} .1154\ 10^{-27} \frac{meter^3\ kg}{second^2} \\ .3537\ 10^{-20} \frac{meter\ \mathrm{meter}(.9111\ 10^{-30}\ kg)^3}{\mathrm{kg}(.9111\ 10^{-30}\ kg)\ \mathrm{second}(.9111\ 10^{-30}\ kg)^2} \\ .1166\ 10^{32}\ meter\ kg \\ .3865\ 10^{-12}\ meter \\ .8492\ 10^{-29} \frac{meter^3\ kg}{second^2} \\ .2810\ 10^{-20}\ meter^2 \\ .1494\ 10^{-24}\ meter^2 \\ .9028\ 10^{16}\ meter^2 \\ .1216\ 10^{44}\ meter\ kg \\ .4830\ 10^{-40}\ meter\ kg \\ .7602\ 10^{-35}\ meter\ kg \end{bmatrix}$$

```
> R6[9,1];
```

$$R6_{9,1}$$

```
> R7 := (linalg[transpose](R6))/(.1098e31*matrix([[13.59,
  .4165e9*meter/(kg^2), .1373e61*second^2/(meter^2),
  .4552e17*second^2/(meter^2*kg), 1.000,
  .3309e9*second^2/(meter*kg), .1760e5*second^2/(meter*kg),
  .1063e46*second^2/(meter*kg), .1432e73*second^2/(meter^2),
  .5687e-11*second^2/(meter^2),
  .8951e-6*second^2/(meter^2)]])/kg);
Error, (in linalg[transpose]) expecting a matrix or vector
> %,matrix([[13.59], [.4165e9*meter/(kg^2)],
  [.1373e61*second^2/(meter^2)], [.4552e17*second^2/(meter^2*kg)],
  [1.000], [.3309e9*second^2/(meter*kg)],
  [.1760e5*second^2/(meter*kg)], [.1063e46*second^2/(meter*kg)],
  [.1432e73*second^2/(meter^2)], [.5687e-11*second^2/(meter^2)],
  [.8951e-6*second^2/(meter^2)]]), [1];
```

$$R6_{9,1}, \begin{bmatrix} 13.59 \\ .4165\ 10^{9} \frac{meter}{kg^2} \\ .1373\ 10^{61} \frac{second^2}{meter^2} \\ .4552\ 10^{17} \frac{second^2}{meter^2\ kg} \\ 1.000 \\ .3309\ 10^{9} \frac{second^2}{meter\ kg} \\ 17600. \frac{second^2}{meter\ kg} \\ .1063\ 10^{46} \frac{second^2}{meter\ kg} \\ .1432\ 10^{73} \frac{second^2}{meter^2} \\ .5687\ 10^{-11} \frac{second^2}{meter^2} \\ .8951\ 10^{-6} \frac{second^2}{meter^2} \end{bmatrix}, [1]$$

```
> matrix([[1/2*me*c^2*alpha^2], [G], [mmilkyway], [alpha], [ev],
  [rbohr], [re], [.1702895113e27*meter],
  [.2425e38*year*c*kg/meter], [me],
  [mw]])/(.6242e19*matrix([[.2177e-17*meter^2*kg/(second^2)],
  [.6673e-10*meter^3/(kg*second^2)], [.2200e42*kg], [.7292e-2],
  [.1602e-18*meter^2*kg/(second^2)], [.5301e-10*meter],
  [.2819e-14*meter], [.1702895113e27*meter], [.2294e54*kg],
  [.9111e-30*kg], [.1434e-24*kg]])*second^2/(meter^2*kg));
```

$$.1602\ 10^{-18} \frac{meter^2\ kg}{second^2}$$

$> R12 := \text{evalm}\left(\frac{.1602\ 10^{-18}\ meter^2\ kg}{second^2}\right)$

$$R12 := .1602\ 10^{-18} \frac{meter^2\ kg}{second^2}$$

$> R11 := \text{evalm}\left(\frac{.1602\ 10^{-18}\ meter^2\ kg}{second^2}\right)$

$$R11 := .1602\ 10^{-18} \frac{meter^2\ kg}{second^2}$$

> $R10 := \text{evalm}\left(\frac{.1602\ 10^{-18}\ meter^2\ kg}{second^2}\right)$

$$R10 := .1602\ 10^{-18}\ \frac{meter^2\ kg}{second^2}$$

> $R8 := \text{evalm}\left(\frac{.1602\ 10^{-18}\ meter^2\ kg}{second^2}\right)$

$$R8 := .1602\ 10^{-18}\ \frac{meter^2\ kg}{second^2}$$

Ako posle prvog racunanja, prvog exe, oznacim niz, samo niz ne celu stranu, dobijam numericke vrednost. Tako sada umesto da ponovo pokrenem celu stranu, celi fajl, oznacujem pojedinacno svaku izdvojenu celinu i tako ispod simbolicnog resenja dobijam i numericko. To je zaista svrsenstvo

> $BB := \dfrac{\begin{bmatrix} \frac{me\ c^2\ \alpha^2}{2} \\ G \\ mmilkyway \\ \alpha \\ ev \\ rbohr \\ re \\ Rg_s \\ M_{sv} \\ me \\ mw \end{bmatrix}}{\begin{bmatrix} \frac{.2177\ 10^{-17}\ meter^2\ kg}{second^2} \\ \frac{.6673\ 10^{-10}\ meter^3}{kg\ second^2} \\ .2200\ 10^{42}\ kg \\ .007292 \\ \frac{.1602\ 10^{-18}\ meter^2\ kg}{second^2} \\ .5301\ 10^{-10}\ meter \\ .2819\ 10^{-14}\ meter \\ .1702895113\ 10^{27}\ meter \\ .2294\ 10^{54}\ kg \\ .9111\ 10^{-30}\ kg \\ .1434\ 10^{-24}\ kg \end{bmatrix}}{hubleconst}$

$$BB := hubleconst$$

```
> BB;
```

hubleconst

```
> AA:=matrix([[1/2*me*c^2*alpha^2], [G], [mmilkyway], [alpha],
  [ev], [rbohr], [re], [.1702895113e27*meter],
  [.2425e38*year*c*kg/meter], [me],
  [mw]])/(1/2000000000000000000000*matrix([[.2177e-17*meter^2*kg/
  (second^2)], [.6673e-10*meter^3/(kg*second^2)], [.2200e42*kg],
  [.7292e-2], [.1602e-18*meter^2*kg/(second^2)],
  [.5301e-10*meter], [.2819e-14*meter], [.1702895113e27*meter],
  [.2294e54*kg], [.9111e-30*kg],
  [.1434e-24*kg]])/meter)/(.1248e42*meter/coulomb);
```

$$AA := .1603\ 10^{-18}\ coulomb$$

```
> (AA);
```

$$.1603\ 10^{-18}\ coulomb$$

```
> AA[10,1];
```

$$(.1603\ 10^{-18}\ coulomb)_{10,\ 1}$$

```
> mw;
```

$$.1434\ 10^{-24}\ kg$$

```
> mmilkyway;
```

$$.2200\ 10^{42}\ kg$$

Iz iste Mirabilis 4 dobio sam i masu w-bozona.

```
> #------UNITS, PHYSICAL CONSTANTS, AND DATA----
  #-------Warren D. Smith 1998-------------
  #This useful file causes MAPLE to know about
  #fundamental physical constants, useful data, and units.

  #I feel cgs, emu, esu units are an abomination.
  #If you want to have no units, go totally dimensionless
  #(for example, the Planck units). If you want to have units,
  #use SI. The cgs, emu, esu systems are a silly halfassed
  attempt
  #to have it both ways and get rid of some units and keep
  others.

  #   The present file features conversion factors to random
  non-SI
  #units like foot, horsepower, pound, ounce. The entire group
  #of units is known to it, so all quantities are dimensioned
  #automatically. Meter, second, coulomb, kelvin, and kg are
  #my fundamental units. (Arguably kelvin is not needed.
  #Also for radiation dose units, I use the "disintegration", e.g.

  #disintegration/second.)
```

```
#  I have so far been unable to stomach the "candela".
#The old definition was...
#candle =  1/60 the luminous intensity of 1 cm^2 of a Blackbody
at the
#melting Temperature of platinum (2042.15 kelvin) = 1.6437
*watt
#= meter^2 / 600000 * sigmasb * platinummelttemp^4;
#a candela is the light intensity from a candle (now redefined
#as "1/683 watt per steradian" of 555nm wavelength light (which
the eye
#is maximally sensitive to).
#Note, this seems to be a lot smaller than the old defn.
#Huh? Then   lumen = candela*steradian = 1/683 *watt;
#lux = lumen/meter^2 = 1/683 *watt/meter^2; candlepower =
candela.
#Yuk!

#I also hate the "radian" and "steradian"; they should be
#dimensionless, in my view.

#   Finally, decibels and bels are another abomination.
#  decibels = 10*bels = 10*log10(Intensity/ReferenceIntensity);
#and for use in auditory work, one uses
#ReferenceIntensity = 1 phon = 10^(-16) *watt/cm^2/sec at 1000
*hertz.
#Idiotic - haven't these guys heard of scientific notation to
deal with
#logarithms?

#  This MAPLE code does not know about precision (usually the
#last 2 digits of our numbers are imprecise). My values
#are CODATA values plus miscellaneous sources like
#CRC handbook. If you really care about errors you have to know
#about the correlations among the errors in the
#fundamental constants (many errors are highly correlated)
#and that would require a lot of extra software, which I
#didn't feel like trying to write.

#Update 1999:
#PJ Mohr BN Taylor
#CODATA recommended values of the fundamental physical constants
1998
#J Phys Chem Ref Data 28 (1999)
#finally came out
#http://physics.nist.gov/cgi-bin/cuu/
#  http://physics.nist.gov/PhysRefData/contents.html
```

```
#The  1998  CODATA
#Recommended Values of the Fundamental Physical
#Constants, Web Version 3.0," available at
#http://physics.nist.gov/constants (National Institute of
#Standards and Technology, Gaithersburg, MD 20899,
#release date 23 July 1999).
#http://physics.nist.gov/cuu/Constants/index.html
#http://physics.nist.gov/constants
#http://www.codata.org/
#http://pdg.lbl.gov/1998/astrorpp.ps
#these sites very recommended - can now download any correlation
coeff too

#A detailed description of the data and its analysis that led to
these
#values will be published by early 2000 in the Journal of
Physical
#and Chemical Reference Data.

#"Review of particle properties", Phys Rev D50 (1994) 1-.
#PRD 54 (July 1996) 1-720.
#C.Caso et al.: Review of particle physics, Europ. Phys. J. C3
(1998) 1-.
#http://pdg.lbl.gov

#---------units (and data):---------------

#prefixes:
zepto := 10^(-21);
atto := 10^(-18);
femto := 10^(-15);
pico := 10^(-12);
nano := 10^(-9);
micro := 10^(-6);
milli := 10^(-3);
centi := 10^(-2);
kilo := 10^3;
mega := 10^6;
giga := 10^9;
tera := 10^12;
peta := 10^15;
exa := 10^18;
zetta := 10^21;

joule := meter^2 * kg / second^2;
```

```
watt := joule/second;
mole := 6.02214199 * 10^(23);  #79 ppb uncert
ampere := coulomb/second;
hertz := 1/second;
newton := meter*kg/second^2;   #force
pascal := newton/meter^2;      #pressure
poise := pascal*second;        #absolute viscosity
stokes := meter^2 /second;     #kinematic viscosity
volt := watt/ampere;
farad := coulomb/volt;
ohm := volt/ampere;
mho := 1/ohm;
siemens := 1/ohm;
weber := volt*second;
tesla := weber/meter^2;
henry := weber/ampere;

sipole := meter*coulomb/second; #my own unit of magentic
monopole charge
#One SIpole is the amount of magnetic charge that would
#experience a force of 1 Newton if placed in a 1 Tesla magnetic
#field.

becquerel := disintegration/second;  #radioactivity unit
gray := joule/kg;  #for measuring absorbed radiation dose
#a sievert is the amount of radiation equivalent in health
effect to 1 gray
#of some kind of standard type of radiation.

minute := 60*second;
hour := 60*minute;
solarday := 24*hour;  #increases 1 millisecond/century
starday := 86164.09 * second;
year := 365.24219879  *solarday;
month := year/12;
century := 100*year;

denier := kg/meter;
dyne := 10^(-5) *newton;
erg := 10^(-7) *joule;

gauss := 10^(-4) * tesla;
maxwell := 10^(-8) *weber;

horsepower := 746 * watt;  #several definitions exist 735 to 746
watt.
```

```
jansky := 10^(-26) * watt * second / meter^2;

oersted := 7.957747 * ampere/meter; #says CRC handbook

parsec := cot(1 * angularsecond) * astronomicalunit;
#3.085678*10^(16) *meter: 3.26*lightyear

lb := .45359237  *kg;  #exact
poundmass := lb;
ounce := lb/16;
shortton := 2000 *lb;
longton :=  2240 *lb;
grain := lb/7000;
slug := 14.59390 *kg;

lbf := 4.4482216152605 * newton: #exact
poundforce := lbf;
psi := lbf/inch^2;  #6895*pascal
torr := 133.322 *pascal;
mmhg := torr;

liter := 10^(-3) *meter^3;

sverdrup := 10^6 *meter^3/second: #volume flux. Used in
oceanography.
kayser := 1/(centi*meter); #used in spectroscopy
cc := (centi*meter)^3;
micron := 10^(-6) * meter;

metricton := 10^3 *kg;  #also "tonne"
#electron-volt
ev := 1.602176462 * 10^(-19) *joule;
km := 10^3 *meter;
mm := 10^(-3) *meter;
cm := 10^(-2) *meter;
astronomicalunit := 149597900 *km:  #earth-sun distance
nauticalmile := 1852*meter;
#nauticalmile := 6076.115486*foot;

angstrom := 10^(-10) * meter;
barn := 10^(-28) *meter^2;
fermi := 10^(-15) *meter;

bar := 10^(5) *pascal;
```

```
abampere := ampere/10;
abcoulomb := coulomb/10;
statampere := 3.335641 * 10^(-10) *ampere;
statcoulomb := 3.335641 * 10^(-10) *coulomb;
curie:= 3.7*10^(10) *becquerel;
roentgen := 2.58 * 10^(-4) *coulomb/kg;
rad := 10^(-2) *gray;
remunit := 10^(-2) *sievert;

pi := evalf(Pi);

radian := 1;
revolution := evalf(2*Pi*radian);
angulardegree := evalf(Pi/180 *radian);
angularminute := angulardegree/60;
angularsecond := angularminute/60;

fullsphere := evalf(4*Pi*steradian);

knot := nauticalmile/hour;
hectare := 10^4 *meter^2;
angstrom := 10^(-10)*meter;
inch := 2.54 * 10^(-2)*meter;
foot := 12*inch;
yard := 3*foot;
printerpoint := 0.13837 *inch;  #or is it inch/72? close
mile := 5280*foot;
acre := mile^(2) /640; #acre := 43560 *foot^2

usgallon := 231 * inch^3;
brgallon := 277.420 *inch^3;
quart := usgallon/4;
pint := quart/2;
cup := pint/2;
gill := cup/2; #british cups, pints, gills are each a bit
bigger
fluidounce := cup/8;
tablespoon := fluidounce/2;
teaspoon  :=  tablespoon/3;
boardfoot := 144 *inch^3;

gram := 10^(-3) *kg;
carat := .2 *gram;

btu := 1.055056 * 10^(3) * joule;
ustherm := 1.054804 * 10^(8) *joule;  #used by US natural gas
```

```
industry

watertripletemp := 273.16 *kelvin; #exact

watertriplepressure := 611.73 *pascal;
platinummelttemp := (1769.0+273.15) *kelvin;
waterfreezetemp := 273.15 *kelvin;
waterboiltemp := 373.15 *kelvin;
#celsius := waterfreeze + kelvin. fahrenheit := celsius * (5/9)
+ 32:

caloriethermo := 4.184 *joule;
calorieintl := 4.1868 *joule;
calorie := calorieintl;

#weapons kiloton is by convention 10^(12) calories.
kiloton := 10^(12) * calorie;
mageaton := 10^(3) * kiloton;

rankine := (5/9) *kelvin;
standardatmosphere := 101325 *pascal;
standardgravity := 9.80665 *meter/second^2;
vsoundair := 331.4 *meter/second;
specheatair := 1010 *joule/kg/kelvin; #at const pressure
densityair := 1.21 * kg/meter^3;
vsoundwater := 1496.7 *meter/second;
densitywater := 1000*kg/meter^3;
specheatwater := 4190 *joule/kg/kelvin; #at const pressure
heatfusionwater := 333 * kilo*joule/kg;
heatvapwater := 2260* kilo*joule/kg;
indexrefwater := 1.33: #at 589 nm

resistivitysilver := 1.587 * 10^(-8) * ohm * meter; #at 293
Kelvin

radgeosync := 42200 * kilo * meter;
vescapeearth := 11200 * meter/second;
muearth := 8.0*10^(22) *joule/tesla; #magnetic dipole moment
efieldearth := 150 * volt/meter;  #down. At earth's surface.
mean.

suntemp := 5780*kelvin;
sunluminosity := 3.846 * 10^(26) * joule/second;
solarconst := evalf(sunluminosity / (4*Pi*astronomicalunit^2));
#varies 2%
```

```
mmilkyway := 2.2*10^(41) *kg;
moceans := 1.4 *10^(21) *kg;

velocorbitalgalaxy := 220 * km/second: #of solar system round
milky way galaxy
velocwrtcosmicbackground := 369.3 * km/second: #+-2.5

disttocenterofmilkyway := 8.0 * mega * parsec;

distproximacentauri := 4.22 * c*year;
#**Alpha  Centauri system;
#Separation between  Alpha  Centauri A and B varies from 11 to
35 AU;
#they take 80 years to orbit around each other.
#Proxima  Centauri is currently 13,000 AUs from A and B; no
orbital
#parameters of it are known.
#  A            B           proxima     sun
# 5800K        5300K       2700K      5800K
#  4.35         4.35        4.22          0 lightyears away
#  Yellow       Orange          Red     Yellow
distandromedagalaxy := 2*10^(22) *meter;
distlargemagellaniccloud := 55*kilo*parsec;
distvirgocluster := 20*mega*parsec;
disttouniverseedge := 10^(26) * meter;
distearthmoon := 384404 *km;  #+3 cm per year
periodmoon := 27 *solarday;  #??? +2 milliseconds/century

distsunmercury := .38  * astronomicalunit;
distsunvenus   := .72  * astronomicalunit;
distsunearth   := 1.0  * astronomicalunit;
distsunmars    := 1.52 * astronomicalunit;
distsunjupiter := 5.20 * astronomicalunit;
distsunsaturn  := 9.5  * astronomicalunit;
distsunuranus  := 19.2 * astronomicalunit;
distsunneptune := 30.0 * astronomicalunit;
distsunpluto   := 39.5 * astronomicalunit;
#pluto has 1 satellite "charon" with about .1 its mass;
#it has day 6.38 earth days.

#radiusearth   := 6371.006 *km:
radiusearth   := 6378.140 *km:#equatorial
radiusmoon    := 1738 *km:

radiusmercury := .38  * radiusearth:
radiusvenus   := .96  * radiusearth:
```

```
radiusmars     := .53  * radiusearth:
radiusjupiter := 10.8 * radiusearth:
radiussaturn  := 9.0  * radiusearth:
radiusuranus  := 4.1  * radiusearth:
radiusneptune := 3.85 * radiusearth:
radiuspluto   := 1137 *km:  #+-8
radiussun     := 695990 *km:  #equatorial
radiussunschwarzschild     := 2.95325008 * km:
radiusmilkyway := 15 * kilo *parsec:
thicknessmilkyway := 1 * kilo *parsec:

mmercury := .33022 * 10^(24) * kg:
mvenus   := 4.8690 * 10^(24) * kg:
mearth   := 5.97370 * 10^(24) * kg:
mmoon    := .073483 * 10^(24) * kg:
mmars    := .64191 * 10^(24) * kg:
mjupiter := 1898.8 * 10^(24) * kg:
msaturn  := 568.50 * 10^(24) * kg:
muranus  := 86.625 * 10^(24) * kg:
mneptune := 102.78 * 10^(24) * kg:
mpluto   := 1.27 * 10^(22) * kg:
msun := 1.98892 * 10^(30) *kg:

hubnum := .5; #could be anywhere .2 to 1.0
hubbleconst := 70*hubnum*km/second/(mega*parsec);
#http://ucsu.colorado.edu/~lisle/main.html
#``The cosmological implications of Hipparcus''
#direct trig parallax distance measurement to nearby Cepheids
with
#Hipparcus satellite. Leads to 10% revision of Hubble constant,
now
#about 60  km/s/Mpc.
#another place claims 60-80 is the range; I'm going with it.

criticaldensity := 3*hubbleconst^2/(8*pi*G); #needed to close
the universe
#matter density is supposed to be .2 to 1.0 times this

entropydensityofuniverse := 2899.3 * (2.853/2.728)^3 * kb / cc;


tempuniversebackground := 2.853 * kelvin:  #plus or minus .002

lightyear := c*year;

#various rough estimates of universe-quantities on
```

```
Misner-Thorne-Wheeler p738:
#max radius 19*10^9 lightyear
#time start to max 3*10^10 year
#time bang to crunch 6*10^10 year
#age now 10^10 year
#radius now 13*10^9 lightyear    note: larger than age
#volume now 3.83*10^79 meter^3
#density at maximum   5*10^(-30) * gram/cc
#rate of increase of radius now   .66 lightyear/year
#amount of matter   5.68*10^(53) kg
#baryon number      3.39*10^(80)

#MTW 29.6p796
#density of universe now is <10^(-28) g/cc and >2*10^(-31) g/cc

#MTW when universe about 10^5 years old, density was 10^(-20)
g/cc and temp 3000K
#and then:
#1. radiation ceased to domaine, now matter
#2. universe became transparent
#3. hydrogen atoms began to form (no longer ionized
perpetually)

#------------------fundamental constants:-----------------

#these constants suffice to define the planck units:

#speed of light in vacuum    exact
c := 299792458 * meter/second:

#boltzmann constant
kb := 1.3806503 * 10^(-23) *joule/kelvin;  #1700 ppb uncert

#permittivity & permeability of vacuum
mu0 := evalf(4*Pi*1.0 * 10^(-7)) *henry/meter; #exact
eps0 := 1/(c^2 * mu0); #exact
#eps0 := 8.854187817 * 10^(-12) *farad/meter
#mu0*eps0*c^2=1

#newton gravitational constant (force = G*m1*m2/r^2)
G := 6.673 * 10^(-11) *newton*meter^2/kg^2;
#+- .010; huge relative uncert .0015

#coulomb law constant (force = coulombconst * q1*q2/r^2)
coulombconst := 1/ (4 * pi *eps0);
```

```
#planck's constant
h := 6.62606876 * 10^(-34) *joule*second;
hbar := 1.054571596 * 10^(-34) *joule*second;
#hbar = evalf(h/(2*Pi)):
#78 ppb uncert

#------------planck length, mass, time, charge:--------------
#These are the fundamental units of
#length, mass, time, charge, temperature
#in a unit system where c=G=hbar=kb=1 and
#where coulombconst*qplanck^2 = G*mplanck^2.

lplanck := sqrt(hbar*G/c^3):
mplanck := sqrt(hbar*c/G):
tplanck := sqrt(hbar*G/c^5):
qplanck := evalf(sqrt(4*Pi*hbar*c*eps0)):
#qplanck / qe = 1/sqrt(alpha), reciprocal sqrt of fine structure
constant!

tempplanck := (mplanck*c^2)/kb:

# lplanck    := 1.616048609*10^(-35) *meter:
# tplanck    := 5.390557920*10^(-44) *second:
# mplanck    := 2.176714074*10^(-8)  *kg:
# qplanck    := 1.875546788*10^(-18) *coulomb:
# tempplanck := 1.416957021*10^(32)  *kelvin:

# qplanck = 11.7062 charge quanta = sqrt(137).
# mplanck = 2.389527889 * 10^(22) electron masses.

#------other fundamental constants:-----------------

#charge of proton
qe := 1.602176462 * 10^(-19) *coulomb:
#39 ppb uncert

#atomic mass unit
amu := 10^(-3) * kg/mole:
#amu := 1.66053873*10^(-27) *kg:  #79 ppb uncert
#mole is number of carbon-12 atoms in 12 grams, amu is
#1/12 mass of a carbon-12 atom.

#rest mass of electron, proton, neutron, muon, deuteron, alpha
particle
#me := 9.10938188 * 10^(-31) *kg:   #79 ppb uncert
me := 5.48579903 * 10^(-4) * amu:   # +-   .00000013
```

```
me := .510998902 * mega * ev/c^2:  #40 ppb uncert
#failed excited lepton searches: e >86 GeV, muon >=86 GeV,
tau>72 GeV

mp := 1.67262158* 10^(-27) *kg;  #79 ppb uncert
mp := 938.271998 * mega * ev / c^2;   #40 ppb uncert
mp := 1.00727646688 * amu;  # .13ppb uncert

mpbyme := 1836.1526675; #2.1ppb uncert

#mn := 1.6749286 * 10^(-27) *kg:
mn := 1.008664904 * amu;
#    +-.000000014

#mmu := 1.8835327*10^(-28) *kg:
mmu := .113428913 * amu;  # +-   .000000017
mmu := 105.658389 * mega * ev/c^2; #+-.000034  (1998 value)

mdeuteron := 3.3435860 * 10^(-27) *kg;
mdeuteron := 1875.612762 * mega * ev/c^2; #40 ppb
mtriton   := 3.015500 * amu;
m3he      := 3.014932 * amu;
malpha := me / (1.37093354 * 10^(-4));
#malpha :=       4.001505 * amu;
mpi  := 135.0 * mega*ev/c^2; #mass of pi
mpi0 := 139.6 * mega*ev/c^2; #mass of pi_0^{+-}
mtau := 1777.05 * mega * ev / c^2; #+.29, -.26  (1998 value)

#heavy lepton searches supposedly go up to 81.5GeV now with 95%
conf
#nothing charged there. Ackerstaff Euro Phys J C1 (1998) 45
#also 95% conf nothing uncharged below 69GeV

mquarku := 3.25 * mega * ev/c^2; #charge +2/3  (1.5 to 5)
mquarkd := 6    * mega * ev/c^2; #charge -1/3 #??? wrong way ???
(3 to 9)
mquarks := 115 * mega * ev/c^2; #charge -1/3  (60 to 170)
mquarkc := 1.25  * giga * ev/c^2; #charge +2/3  (1.25 +-.15)
mquarkb := 4.25  * giga * ev/c^2; #charge -1/3  (4.25 +- .15)
mquarkt := 174.3 * giga * ev/c^2; #charge +2/3. 174.3+-5.1
#all quarks spin 1/2, baryon # 1/3, RGB or anti-RGB color.

mw := 80.41  * giga * ev/c^2; #+-.4 Gev. Charge +-1. Spin 1. W
boson.
mz := 91.187 * giga * ev/c^2; #+-.031 Gev. Charge 0. Spin 1. Z
boson.
```

```
#particle mean lifetimes
meanlifemu := 2.19703 * micro * second;#uncert .00004
meanlifetau := .2900 * pico * second:  #+-.0012
meanlifen := 888.6 * second: #+- 3.5 second
#meanlifep > 10^31 years for some investigated modes

#Bohr magneton
bohrmag := qe*hbar/(2*me);
#bohrmag = mue/1.001159652;
#bohrmag := 9.2740154 * 10^(-24) *joule/tesla;

#Nuclear magneton
nucmag := qe*hbar/(2*mp);
#nucmag := 5.0507866*10^(-27) * joule/tesla;

#magnetic moment of electron, proton, neutron, muon, deuteron
#mue := 9.2847701 * 10^(-24) *joule/tesla;
mue := 1.001159652193 * bohrmag;
# +-    .000000000010

#mup := 1.41060761 * 10^(-26) *joule/tesla;
mup := 2.792847386 * nucmag;
# +-    .000000063

#mun := 9.6623707 * 10^(-27) *joule/tesla:
mun := 1.91304275 * nucmag; #has negative sign, incidentally
#     +-.00000045

mumu := 4.4904514 * 10^(-26) *joule/tesla;
mudeuteron := 4.3307375 * 10^(-27) *joule/tesla;

#------------"atomic units":--------------
#mass     me
#charge   qe
#action   hbar
#length   rbohr
#energy   hartree

#Bohr radius (estimate, for hydrogen atom)
rbohr := evalf(4*Pi*eps0*hbar^2/(me*qe^2));
#rbohr := 5.29177208 * 10^(-11) *meter: #3.7ppb

#hartree energy unit, about 27 ev
#hartree := 2*rydberg*h*c := 4.3598 * 10^(-18) *joule:
hartree := hbar^2 / (me*rbohr^2);
```

```
atomictimeunit := hbar / hartree;
atomicvelocityunit := rbohr / atomictimeunit;   #about c/137
atomicforceunit := hartree / rbohr;
atomicmomentumunit := hbar / rbohr;
atomiccurrentunit := qe / atomictimeunit;
atomicefieldunit := hartree/(qe*rbohr);
atomicpotentialunit := hartree/qe;
atomicedipoleunit := qe*rbohr;
atomicmagfieldunit := hbar / (qe*rbohr^2);

atomicmagdipoleunit :=  2*bohrmag;

#------derived constants:-----------------

#magnetic flux quantum
phi0 := h/(2*qe);
#phi0 := 2.06783461 * 10^(-15) *weber

#alpha = fine structure constant
#alpha := 1/137.0359895;
alpha := evalf(qe^2 / (4*Pi*eps0*hbar*c));

#stefan-boltzmann constant
sigmasb := evalf(Pi^2*kb^4/(60*hbar^3*c^2));
#sigmasb :=  5.670400*10^(-8) *watt/meter^2/kelvin^4; #7000 ppb

#first radiation constant
c1radiation := evalf(2*Pi*h*c^2);
#c1radiation := 3.7417749 * 10^(-16) watt/meter^2;
c2radiation := h*c/kb;
#c2radiation := 0.01438769 *meter*kelvin;
#The max intensity lambda in blackbody radiation is
#wienconst*T*cm/kelvin, where
wienconst := c2radiation / 4.965114231;
#wienconst := 0.2897756 *cm/kelvin:

#rydberg (approx hydrogen waves per meter, infinite mass nuc)
rydberg := me*c*alpha^2/(2*h);
#rydberg := 10973731.56834(24) /meter:

#classical electron radius
#re := 2.817940285 * 10^(-15) *meter: #11 ppb
re := alpha^2 * rbohr;

#compton wavelengths of electron, proton, neutron, muon
```

```
e_compton := h/(me*c);
p_compton := h/(mp*c);
n_compton := h/(mn*c);
mu_compton := h/(mmu*c);

fermicouplingconst := 1.16639 * 10^(-5) / (giga * ev)^2; #9000
ppb
sinsquaredweakmixingangle := 0.23124;  #.001 relative uncert
#codata says .2235 +- .0023

strongcouplingconst :=.119;
```

$$zepto := \frac{1}{1000000000000000000000}$$

$$atto := \frac{1}{1000000000000000000}$$

$$femto := \frac{1}{1000000000000000}$$

$$pico := \frac{1}{1000000000000}$$

$$nano := \frac{1}{1000000000}$$

$$micro := \frac{1}{1000000}$$

$$milli := \frac{1}{1000}$$

$$centi := \frac{1}{100}$$

$$kilo := 1000$$

$$mega := 1000000$$

$$giga := 1000000000$$

$$tera := 1000000000000$$

$$peta := 1000000000000000$$

$$exa := 1000000000000000000$$

$$zetta := 1000000000000000000000$$

$$joule := \frac{meter^2\, kg}{second^2}$$

$$watt := \frac{meter^2\, kg}{second^3}$$

$$mole := .6022\; 10^{24}$$

$$ampere := \frac{coulomb}{second}$$

$$hertz := \frac{1}{second}$$

$$newton := \frac{meter\ kg}{second^2}$$

$$pascal := \frac{kg}{meter\ second^2}$$

$$poise := \frac{kg}{meter\ second}$$

$$stokes := \frac{meter^2}{second}$$

$$volt := \frac{meter^2\ kg}{second^2\ coulomb}$$

$$farad := \frac{coulomb^2\ second^2}{meter^2\ kg}$$

$$ohm := \frac{meter^2\ kg}{second\ coulomb^2}$$

$$mho := \frac{second\ coulomb^2}{meter^2\ kg}$$

$$siemens := \frac{second\ coulomb^2}{meter^2\ kg}$$

$$weber := \frac{meter^2\ kg}{second\ coulomb}$$

$$tesla := \frac{kg}{second\ coulomb}$$

$$henry := \frac{meter^2\ kg}{coulomb^2}$$

$$sipole := \frac{meter\ coulomb}{second}$$

$$becquerel := \frac{disintegration}{second}$$

$$gray := \frac{meter^2}{second^2}$$

$$minute := 60\ second$$

$$hour := 3600\ second$$

$$solarday := 86400\ second$$

$$starday := 86164.09\ second$$

$$year := .3155\ 10^{8}\ second$$

$$month := .2629\ 10^{7}\ second$$

$$century := .3155\ 10^{10}\ second$$

$$denier := \frac{kg}{meter}$$

$$dyne := \frac{1}{100000}\ \frac{meter\ kg}{second^2}$$

$$erg := \frac{1}{10000000}\ \frac{meter^2\ kg}{second^2}$$

$$gauss := \frac{1}{10000}\ \frac{kg}{second\ coulomb}$$

$$maxwell := \frac{1}{100000000}\ \frac{meter^2\ kg}{second\ coulomb}$$

$$horsepower := 746\ \frac{meter^2\ kg}{second^3}$$

$$jansky := \frac{1}{10000000000000000000000000}\ \frac{kg}{second^2}$$

$$oersted := 7.957747\ \frac{coulomb}{second\ meter}$$

$$parsec := .3085\ 10^{17}\ meter$$

$$lb := .45359237\ kg$$

$$poundmass := .45359237\ kg$$

$$ounce := .02835\ kg$$

$$shortton := 907.2\ kg$$

$$longton := 1016.\ kg$$

$$grain := .00006480\ kg$$

$$slug := 14.59390\ kg$$

$$poundforce := 4.4482216152605\ \frac{meter\ kg}{second^2}$$

$$\psi := 6894.\ \frac{kg}{meter\ second^2}$$

$$torr := 133.322\ \frac{kg}{meter\ second^2}$$

$$mmhg := 133.322\ \frac{kg}{meter\ second^2}$$

$$liter := \frac{1}{1000}\, meter^3$$

$$kayser := 100\, \frac{1}{meter}$$

$$cc := \frac{1}{1000000}\, meter^3$$

$$micron := \frac{1}{1000000}\, meter$$

$$metricton := 1000\, kg$$

$$ev := .1602\ 10^{-18}\, \frac{meter^2\, kg}{second^2}$$

$$km := 1000\, meter$$

$$mm := \frac{1}{1000}\, meter$$

$$cm := \frac{1}{100}\, meter$$

$$nauticalmile := 1852\, meter$$

$$angstrom := \frac{1}{10000000000}\, meter$$

$$barn := \frac{1}{10000000000000000000000000000}\, meter^2$$

$$fermi := \frac{1}{1000000000000000}\, meter$$

$$bar := 100000\, \frac{kg}{meter\ second^2}$$

$$abampere := \frac{1}{10}\, \frac{coulomb}{second}$$

$$abcoulomb := \frac{1}{10}\, coulomb$$

$$statampere := .3336\ 10^{-9}\, \frac{coulomb}{second}$$

$$statcoulomb := .3336\ 10^{-9}\, coulomb$$

$$curie := .3700\ 10^{11}\, \frac{disintegration}{second}$$

$$roentgen := .0002580\, \frac{coulomb}{kg}$$

$$rad := \frac{1}{100}\, \frac{meter^2}{second^2}$$

$$remunit := \frac{1}{100}\,sievert$$

$$\pi := 3.142$$

$$radian := 1$$

$$revolution := 6.284$$

$$angulardegree := .01746$$

$$angularminute := .0002910$$

$$angularsecond := .4850\ 10^{-5}$$

$$fullsphere := 12.57\ steradian$$

$$knot := \frac{463}{900}\,\frac{meter}{second}$$

$$hectare := 10000\ meter^2$$

$$angstrom := \frac{1}{10000000000}\,meter$$

$$inch := .02540\ meter$$

$$foot := .3048\ meter$$

$$yard := .9144\ meter$$

$$printerpoint := .003515\ meter$$

$$mile := 1609.\ meter$$

$$acre := 4045.\ meter^2$$

$$usgallon := .003786\ meter^3$$

$$brgallon := .004547\ meter^3$$

$$quart := .0009465\ meter^3$$

$$pint := .0004733\ meter^3$$

$$cup := .0002367\ meter^3$$

$$gill := .0001184\ meter^3$$

$$fluidounce := .00002959\ meter^3$$

$$tablespoon := .00001480\ meter^3$$

$$teaspoon := .4933\ 10^{-5}\ meter^3$$

$$boardfoot := .002360\ meter^3$$

$$gram := \frac{1}{1000}\,kg$$

$$carat := .0002000\ kg$$

$$btu := 1055.\ \frac{meter^2\ kg}{second^2}$$

$$ustherm := .1055\ 10^9\ \frac{meter^2\ kg}{second^2}$$

$$watertripletemp := 273.16\ kelvin$$

$$watertriplepressure := 611.73\ \frac{kg}{meter\ second^2}$$

$$platinummelttemp := 2042.\ kelvin$$

$$waterfreezetemp := 273.15\ kelvin$$

$$waterboiltemp := 373.15\ kelvin$$

$$caloriethermo := 4.184\ \frac{meter^2\ kg}{second^2}$$

$$calorieintl := 4.1868\ \frac{meter^2\ kg}{second^2}$$

$$calorie := 4.1868\ \frac{meter^2\ kg}{second^2}$$

$$kiloton := .4187\ 10^{13}\ \frac{meter^2\ kg}{second^2}$$

$$mageaton := .4187\ 10^{16}\ \frac{meter^2\ kg}{second^2}$$

$$rankine := \frac{5}{9}\ kelvin$$

$$standardatmosphere := 101325\ \frac{kg}{meter\ second^2}$$

$$standardgravity := 9.80665\ \frac{meter}{second^2}$$

$$vsoundair := 331.4\ \frac{meter}{second}$$

$$specheatair := 1010\ \frac{meter^2}{second^2\ kelvin}$$

$$densityair := 1.21\ \frac{kg}{meter^3}$$

$$vsoundwater := 1496.7\ \frac{meter}{second}$$

$$densitywater := 1000\ \frac{kg}{meter^3}$$

$$specheatwater := 4190\ \frac{meter^2}{second^2\ kelvin}$$

$$heatfusionwater := 333000\ \frac{meter^2}{second^2}$$

$$heatvapwater := 2260000 \frac{meter^2}{second^2}$$

$$resistivitysilver := .1587\ 10^{-7} \frac{meter^3\ kg}{second\ coulomb^2}$$

$$radgeosync := 42200000\ meter$$

$$vescapeearth := 11200 \frac{meter}{second}$$

$$muearth := .8000\ 10^{23} \frac{meter^2\ coulomb}{second}$$

$$efieldearth := 150 \frac{meter\ kg}{second^2\ coulomb}$$

$$suntemp := 5780\ kelvin$$

$$sunluminosity := .3846\ 10^{27} \frac{meter^2\ kg}{second^3}$$

$$solarconst := 1368. \frac{kg}{second^3}$$

$$mmilkyway := .2200\ 10^{42}\ kg$$

$$moceans := .1400\ 10^{22}\ kg$$

$$disttocenterofmilkyway := .2468\ 10^{24}\ meter$$

$$distproximacentauri := .3992\ 10^{17}\ meter$$

$$distandromedagalaxy := 20000000000000000000000\ meter$$

$$distlargemagellaniccloud := .1697\ 10^{22}\ meter$$

$$distvirgocluster := .6170\ 10^{24}\ meter$$

$$disttouniverseedge := 100000000000000000000000000\ meter$$

$$distearthmoon := 384404000\ meter$$

$$periodmoon := 2332800\ second$$

$$distsunmercury := .5685\ 10^{11}\ meter$$

$$distsunvenus := .1077\ 10^{12}\ meter$$

$$distsunearth := .1496\ 10^{12}\ meter$$

$$distsunmars := .2274\ 10^{12}\ meter$$

$$distsunjupiter := .7779\ 10^{12}\ meter$$

$$distsunsaturn := .1421\ 10^{13}\ meter$$

$$distsunuranus := .2872\ 10^{13}\ meter$$

$$distsunneptune := .4488\ 10^{13}\ meter$$

$$distsunpluto := .5909\ 10^{13}\ meter$$

$$hubnum := .5$$

$$hubbleconst := .1135\ 10^{-17}\ \frac{1}{second}$$

$$criticaldensity := .2304\ 10^{-26}\ \frac{kg}{meter^3}$$

$$entropydensityofuniverse := .4579\ 10^{-13}\ \frac{kg}{meter\ second^2\ kelvin}$$

$$lightyear := .9459\ 10^{16}\ meter$$

$$kb := .1381\ 10^{-22}\ \frac{meter^2\ kg}{second^2\ kelvin}$$

$$\mu 0 := .1257\ 10^{-5}\ \frac{meter\ kg}{coulomb^2}$$

$$eps0 := .8854\ 10^{-11}\ \frac{second^2\ coulomb^2}{meter^3\ kg}$$

$$G := .6673\ 10^{-10}\ \frac{meter^3}{kg\ second^2}$$

$$coulombconst := .8988\ 10^{10}\ \frac{meter^3\ kg}{second^2\ coulomb^2}$$

$$h := .6626\ 10^{-33}\ \frac{meter^2\ kg}{second}$$

$$hbar := .1055\ 10^{-33}\ \frac{meter^2\ kg}{second}$$

$$mp := .1673\ 10^{-26}\ kg$$

$$mp := .1673\ 10^{-26}\ kg$$

$$mp := .1673\ 10^{-26}\ kg$$

$$mpbyme := 1836.1526675$$

$$mn := .1676\ 10^{-26}\ kg$$

$$mmu := .1884\ 10^{-27}\ kg$$

$$mmu := .1885\ 10^{-27}\ kg$$

$$mdeuteron := .3344\ 10^{-26}\ kg$$

$$mdeuteron := .3345\ 10^{-26}\ kg$$

$$mtriton := .5010\ 10^{-26}\ kg$$

$$m3he := .5008\ 10^{-26}\ kg$$

$$malpha := .6646\ 10^{-26}\ kg$$

$$mpi := .2407\ 10^{-27}\ kg$$

$$mpi0 := .2489\ 10^{-27}\ kg$$

$$mtau := .3168\ 10^{-26}\ kg$$

$$mquarku := .5795\ 10^{-29}\ kg$$

$$mquarkd := .1070\ 10^{-28}\ kg$$

$$mquarks := .2050\ 10^{-27}\ kg$$

$$mquarkc := .2229\ 10^{-26}\ kg$$

$$mquarkb := .7578\ 10^{-26}\ kg$$

$$mquarkt := .3108\ 10^{-24}\ kg$$

$$mw := .1434\ 10^{-24}\ kg$$

$$mz := .1626\ 10^{-24}\ kg$$

$$meanlifemu := .2197\ 10^{-5}\ second$$

$$bohrmag := .9275\ 10^{-23}\ \frac{meter^2\ coulomb}{second}$$

$$nucmag := .5050\ 10^{-26}\ \frac{meter^2\ coulomb}{second}$$

$$mue := .9284\ 10^{-23}\ \frac{meter^2\ coulomb}{second}$$

$$mup := .1410\ 10^{-25}\ \frac{meter^2\ coulomb}{second}$$

$$mun := .9661\ 10^{-26}\ \frac{meter^2\ coulomb}{second}$$

$$mumu := .4490\ 10^{-25}\ \frac{meter^2\ coulomb}{second}$$

$$mudeuteron := .4331\ 10^{-26}\ \frac{meter^2\ coulomb}{second}$$

$$rbohr := .5301\ 10^{-10}\ meter$$

$$hartree := .4349\ 10^{-17}\ \frac{meter^2\ kg}{second^2}$$

$$atomictimeunit := .2426\ 10^{-16}\ second$$

$$atomicvelocityunit := .2185\ 10^{7}\ \frac{meter}{second}$$

$$atomicforceunit := .8204\ 10^{-7}\ \frac{meter\ kg}{second^2}$$

$$atomicmomentumunit := .1990\ 10^{-23}\ \frac{meter\ kg}{second}$$

$$atomiccurrentunit := .006603\ \frac{coulomb}{second}$$

$$atomicefieldunit := .5122\ 10^{12} \frac{meter\ kg}{second^2\ coulomb}$$

$$atomicpotentialunit := 27.15 \frac{meter^2\ kg}{second^2\ coulomb}$$

$$atomicedipoleunit := .8492\ 10^{-29}\ coulomb\ meter$$

$$atomicmagfieldunit := 234400. \frac{kg}{second\ coulomb}$$

$$atomicmagdipoleunit := .1855\ 10^{-22} \frac{meter^2\ coulomb}{second}$$

$$\phi 0 := .2068\ 10^{-14} \frac{meter^2\ kg}{second\ coulomb}$$

$$\alpha := .007292$$

$$sigmasb := .5671\ 10^{-7} \frac{kg}{second^3\ kelvin^4}$$

$$c1radiation := .3742\ 10^{-15} \frac{meter^4\ kg}{second^3}$$

$$c2radiation := .01438\ meter\ kelvin$$

$$wienconst := .002896\ meter\ kelvin$$

$$rydberg := .1096\ 10^{8} \frac{1}{meter}$$

$$re := .2819\ 10^{-14}\ meter$$

$$e\_compton := .2426\ 10^{-11}\ meter$$

$$p\_compton := .1321\ 10^{-14}\ meter$$

$$n\_compton := .1319\ 10^{-14}\ meter$$

$$mu\_compton := .1172\ 10^{-13}\ meter$$

$$fermicouplingconst := .4544\ 10^{15} \frac{second^4}{meter^4\ kg^2}$$

$$sinsquaredweakmixingangle := .23124$$

$$strongcouplingconst := .119$$

```
> qe;
```

$$.1602\ 10^{-18}\ coulomb$$

```
> me*c^2*alpha^2/2;
```

$$.2177\ 10^{-17} \frac{meter^2\ kg}{second^2}$$

```
> (me*c^2*alpha^2/2)/ev;
```

$$13.59$$

```
> psifun:=sqrt(2/rbohr)*sin(pi*x[n]/rbohr);
```

$$psifun := 194200. \sqrt{\frac{1}{meter}} \sin\left(.5927\ 10^{11} \frac{1_n}{meter}\right)$$

```
> evalf(%);
```

$$194200. \sqrt{\frac{1}{meter}} \sin\left(.5927\ 10^{11} \frac{1_n}{meter}\right)$$

```
> R13 := simplify(.1942e6*(1/meter)^(1/2)*sin(.5927e11*2/meter));
```

$$R13 := 194200. \sqrt{\frac{1}{meter}} \sin\left(.1185\ 10^{12} \frac{1}{meter}\right)$$

```
> n:=matrix([[1.], [2.], [3.], [4.]]);
```

$$n := \begin{bmatrix} 1. \\ 2. \\ 3. \\ 4. \end{bmatrix}$$

```
> x:=rbohr;
```

$$x := .5301\ 10^{-10}\ meter$$

```
> psifun:=(sqrt(2./(x)))*sin(n*pi/rbohr);
```

$$psifun := 194200. \sqrt{\frac{1}{meter}} \sin\left(.5927\ 10^{11} \frac{n}{meter}\right)$$

> $R28 := \text{evalm}(psifun)$

$$R28 := \begin{bmatrix} 194200. \sqrt{\frac{1}{meter}} \sin\left(.5927\ 10^{11} \frac{1}{meter}\right) \\ 194200. \sqrt{\frac{1}{meter}} \sin\left(.1185\ 10^{12} \frac{1}{meter}\right) \\ 194200. \sqrt{\frac{1}{meter}} \sin\left(.1778\ 10^{12} \frac{1}{meter}\right) \\ 194200. \sqrt{\frac{1}{meter}} \sin\left(.2371\ 10^{12} \frac{1}{meter}\right) \end{bmatrix}$$

> $R29 := linalg_{transpose}(R28)$

$R29 :=$

$$\left[194200. \sqrt{\frac{1}{meter}} \sin\left(.5927\ 10^{11} \frac{1}{meter}\right), 194200. \sqrt{\frac{1}{meter}} \sin\left(.1185\ 10^{12} \frac{1}{meter}\right), 194200. \sqrt{\frac{1}{meter}} \sin\left(.1778\ 10^{12} \frac{1}{meter}\right), 194200. \sqrt{\frac{1}{meter}} \sin\left(.2371\ 10^{12} \frac{1}{meter}\right)\right]$$

> $R30 := [linalg_{rowdim}(R29), linalg_{coldim}(R29)]$

$$R30 := [1, 4]$$

```
> .1942e6*((sin(.5927e11*1/meter)/meter))^(1/2);
```

$$194200.\sqrt{\frac{\sin\left(.5927\ 10^{11}\ \frac{1}{meter}\right)}{meter}}$$

> $R27 := \text{simplify}\left(194200.\left(\frac{1\ \sin\left(\frac{.5927\ 10^{11}}{meter}\right)}{meter}\right)^{\left(\frac{1}{2}\right)}\right)$

$$R27 := 194200.\sqrt{\frac{\sin\left(.5927\ 10^{11}\ \frac{1}{meter}\right)}{meter}}$$

> **evala(sin(pi/rbohr));**

$$\sin\left(.5927\ 10^{11}\ \frac{1}{meter}\right)$$

> $R26 := \text{evalf}(psifun, 5)$

$$R26 := 194200.\sqrt{\frac{1}{meter}}\ \sin\left(.5927\ 10^{11}\ \frac{n}{meter}\right)$$

> $R25 := \text{evalm}\left(194200.\left(\frac{1\ \sin\left(\frac{.5927\ 10^{11}\ \text{array}(1\ ..\ 4, 1\ ..\ 1, [(1, 1) = 1., (2, 1) = 2., (3, 1) = 3., (4, 1) = 4.])}{meter}\right)}{meter}\right)^{\left(\frac{1}{2}\right)}\right)$

$$R25 := 194200.\sqrt{\begin{bmatrix}\frac{\sin\left(.5927\ 10^{11}\ \frac{1}{meter}\right)}{meter}\\ \frac{\sin\left(.1185\ 10^{12}\ \frac{1}{meter}\right)}{meter}\\ \frac{\sin\left(.1778\ 10^{12}\ \frac{1}{meter}\right)}{meter}\\ \frac{\sin\left(.2371\ 10^{12}\ \frac{1}{meter}\right)}{meter}\end{bmatrix}}$$

> $R24 := \text{evalm}\left(194200.\left(\frac{1}{meter}\right)^{\left(\frac{1}{2}\right)}\sin\left(\frac{.5927\ 10^{11}\ \text{array}(1\ ..\ 4, 1\ ..\ 1, [(1, 1) = 1., (2, 1) = 2., (3, 1) = 3., (4, 1) = 4.])}{meter}\right)\right)$

$$R24 := \begin{bmatrix} 194200.\sqrt{\frac{1}{meter}}\sin\left(.5927\ 10^{11}\frac{1}{meter}\right) \\ 194200.\sqrt{\frac{1}{meter}}\sin\left(.1185\ 10^{12}\frac{1}{meter}\right) \\ 194200.\sqrt{\frac{1}{meter}}\sin\left(.1778\ 10^{12}\frac{1}{meter}\right) \\ 194200.\sqrt{\frac{1}{meter}}\sin\left(.2371\ 10^{12}\frac{1}{meter}\right) \end{bmatrix}$$

```
> R22 := evalf(.1942e6*(1/meter)^(1/2)*sin(.5927e11*array(1 .. 4,1
.. 1,[(1, 1) = 1., (2, 1) = 2., (3, 1) = 3., (4, 1) =
4.])/meter));
```

$$R22 := 194200.\sqrt{\frac{1}{meter}}\sin\left(\frac{.5927\ 10^{11}\begin{bmatrix}1.\\2.\\3.\\4.\end{bmatrix}}{meter}\right)$$

> $R23 := \text{evalm}\left(194200.\left(\frac{1}{meter}\right)^{\left(\frac{1}{2}\right)}\sin\left(\frac{.5927\ 10^{11}\ \text{array}(1 .. 4, 1 .. 1, [(1, 1) = 1., (2, 1) = 2., (3, 1) = 3., (4, 1) = 4.])}{meter}\right)\right)$

$$R23 := \begin{bmatrix} 194200.\sqrt{\frac{1}{meter}}\sin\left(.5927\ 10^{11}\frac{1}{meter}\right) \\ 194200.\sqrt{\frac{1}{meter}}\sin\left(.1185\ 10^{12}\frac{1}{meter}\right) \\ 194200.\sqrt{\frac{1}{meter}}\sin\left(.1778\ 10^{12}\frac{1}{meter}\right) \\ 194200.\sqrt{\frac{1}{meter}}\sin\left(.2371\ 10^{12}\frac{1}{meter}\right) \end{bmatrix}$$

```
> R14 :=evalf(psifun);
```

$$R14 := 194200.\sqrt{\frac{1}{meter}}\sin\left(.5927\ 10^{11}\frac{n}{meter}\right)$$

> $R21 := \text{simplify}(R14)$

$$R21 := 194200.\sqrt{\frac{1}{meter}}\sin\left(.5927\ 10^{11}\frac{n}{meter}\right)$$

>

>

> $R15 := \text{sprintf}(\%a, \text{evalm}(R14))$

R15 := "array(1 .. 4, 1 .. 1,[(4, 1)=.1942e6*(1/meter)^(1/2)*sin(.2371e12/meter),(1, 1)=.1942e\

6*(1/meter)^(1/2)*sin(.5927e11/meter),(2, 1)=.1942e6*(1/meter)^(1/2)*sin(.1185e12/meter),(\
3, 1)=.1942e6*(1/meter)^(1/2)*sin(.1778e12/meter)])"

```
> R16 := parse(R15)
```

$$R16 := \operatorname{array}\left(1..4, 1..1, \left[(4,1) = 194200.\sqrt{\frac{1}{meter}}\sin\left(.2371\ 10^{12}\frac{1}{meter}\right), (1,1) = 194200.\sqrt{\frac{1}{meter}}\sin\left(.5927\ 10^{11}\frac{1}{meter}\right), (2,1) = 194200.\sqrt{\frac{1}{meter}}\sin\left(.1185\ 10^{12}\frac{1}{meter}\right), (3,1) = 194200.\sqrt{\frac{1}{meter}}\sin\left(.1778\ 10^{12}\frac{1}{meter}\right)\right]\right)$$

```
> psifun:=matrix([[.1942e6*sqrt(1/meter)*sin(.5927e11*x/meter)],
  [.1942e6*sqrt(1/meter)*sin(.1185e12*x/meter)],
  [.1942e6*sqrt(1/meter)*sin(.1778e12*x/meter)],
  [.1942e6*sqrt(1/meter)*sin(.2371e12*x/meter)]]);
```

$$psifun := \begin{bmatrix} -79.10\sqrt{\frac{1}{meter}} \\ -230.1\sqrt{\frac{1}{meter}} \\ -43.11\sqrt{\frac{1}{meter}} \\ 704.8\sqrt{\frac{1}{meter}} \end{bmatrix}$$

```
> matrix([[.1942e6*sqrt(1/meter)*sin(.5927e11*x/meter)],
  [.1942e6*sqrt(1/meter)*sin(.1185e12*x/meter)],
  [.1942e6*sqrt(1/meter)*sin(.1778e12*x/meter)],
  [.1942e6*sqrt(1/meter)*sin(.2371e12*x/meter)]]);
```

$$\begin{bmatrix} -79.10\sqrt{\frac{1}{meter}} \\ -230.1\sqrt{\frac{1}{meter}} \\ -43.11\sqrt{\frac{1}{meter}} \\ 704.8\sqrt{\frac{1}{meter}} \end{bmatrix}$$

$$> R17 := \operatorname{sprintf}\left(\%a, \operatorname{evalm}\left(\operatorname{array}\left(1..4, 1..1, \left[(1,1) = 194200.\left(\frac{1}{meter}\right)^{\left(\frac{1}{2}\right)}\sin\left(\frac{.5927\ 10^{11}\ x}{meter}\right),\right.\right.\right.\right.$$

$$(2,1) = 194200.\left(\frac{1}{meter}\right)^{\left(\frac{1}{2}\right)} \sin\left(\frac{.1185\ 10^{12}\,x}{meter}\right),$$

$$(3,1) = 194200.\left(\frac{1}{meter}\right)^{\left(\frac{1}{2}\right)} \sin\left(\frac{.1778\ 10^{12}\,x}{meter}\right),$$

$$(4,1) = 194200.\left(\frac{1}{meter}\right)^{\left(\frac{1}{2}\right)} \sin\left(\frac{.2371\ 10^{12}\,x}{meter}\right)\Bigg]\Bigg)\Bigg)\Bigg)$$

R17 := "array(1 .. 4, 1 .. 1,[(4, 1)=704.8*(1/meter)^(1/2),(1, 1)=-79.10*(1/meter)^(1/2),(2, 1)=-\
230.1*(1/meter)^(1/2),(3, 1)=-43.11*(1/meter)^(1/2)])"

```
> R17 := .1942e6*(1/meter)^(1/2)*sin(.5927e11*x/meter),(2,
  1)=.1942e6*(1/meter)^(1/2)*sin(.1185e12*x/meter),(3,
  1)=.1942e6*(1/meter)^(1/2)*sin(.1778e12*x/meter),(4,
  1)=.1942e6*(1/meter)^(1/2)*sin(.2371e12*x/meter);
```

$$R17 := -79.10\sqrt{\frac{1}{meter}},\ (2,1) = -230.1\sqrt{\frac{1}{meter}},\ (3,1) = -43.11\sqrt{\frac{1}{meter}},$$

$$(4,1) = 704.8\sqrt{\frac{1}{meter}}$$

$$\frac{d^2}{dx^2}\left(\frac{1}{4}\cdot \mathbf{i}\cdot m_{sb}\cdot\frac{c^4}{\pi^2\cdot\nu^2}\right) + \frac{d^2}{dy^2}\left(\frac{1}{4}\cdot \mathbf{i}\cdot m_{sb}\cdot\frac{c^4}{\pi^2\cdot\nu^2}\right)\ \ldots\ = 6.626\times 10^{-27}\ \mathrm{gm\cdot cm^2\cdot sec^{-2}}$$

$$+\frac{d^2}{dz^2}\left(\frac{1}{4}\cdot \mathbf{i}\cdot m_{sb}\cdot\frac{c^4}{\pi^2\cdot\nu^2}\right)\ \ldots$$

$$+\frac{(2\pi\cdot\nu)^2}{\mathrm{i}\cdot c^2}\cdot\left(\frac{1}{4}\cdot \mathbf{i}\cdot m_{sb}\cdot\frac{c^4}{\pi^2\cdot\nu^2}\right)$$

$$r_{stanb} := 2.066\times 10^{-7}\cdot \mathrm{cm}$$

$$\frac{\left(\frac{H_{sb}{}^2}{2} - \frac{4}{3}\cdot\pi\cdot G\cdot\rho_{sb1}\right)\cdot m_{sb}\cdot r_{stanb}{}^2}{1.602} = 6.627\times 10^{-27}\ \mathrm{gm\cdot cm^2\cdot sec^{-2}} \qquad \psi := \frac{c^4}{\pi^2\cdot\nu^2}$$

```
> diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), x), x)+diff(diff((1/4
  )*I*m[sb]*c^4/(pi^2*v^2), y)+diff(diff((1/4
  )*I*m[sb]*c^4/(pi^2*v^2), z),
  z)+((2*pi*v)^2/(I*c^2))*(1/4)*I*me*c^4/(pi^2*v^2));
Error, wrong number (or type) of parameters in function diff
> me;
```

$$.9111\ 10^{-30}\ kg$$

```
> x:=1;y:=1;z:=1;
```

$$x := 1$$
$$y := 1$$
$$z := 1$$

```
> diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), x), x);
Error, wrong number (or type) of parameters in function diff
> diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), y), y);
Error, wrong number (or type) of parameters in function diff
> diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), z), z);
Error, wrong number (or type) of parameters in function diff
> with(ODE):
Error, (in with) undefined package , ODE
> diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), x),
  x)*psi2(r)+diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), y),
  y)*psi2(r)+diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), z),
  z)*psi2(r)-(2*pi*v)^2/(I*c^2)*((1/4)*m[sb]*(c^4/(pi^2*v^2)))*psi
  2(r);
Error, wrong number (or type) of parameters in function diff
> psi2(r):=1/4*I*m[sb]*c^4/(pi^2*v^2);
```

$$\psi 2(r) := .2046\ 10^{33} \frac{I\, m_{sb}\, meter^4}{second^4\, v^2}$$

```
> with(DEtools):
> ode_2:=diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), x),
  x)*psi2(x,y,z)+diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), y),
  y)*psi2(x,y,z)+diff(diff((1/4 )*I*m[sb]*c^4/(pi^2*v^2), z),
  z)*psi2(x,y,z)+(2*pi*v)^2/(I*c^2)*((1/4)*m[sb]*(c^4/(pi^2*v^2)))
  *psi2(x,y,z);
Error, wrong number (or type) of parameters in function diff
> ODE
>
>
>
>
Warning, premature end of input
> with(ODEtools):
>  ode1:=diff((diff(psi8(x2)),x2,x2)+2*me/(hbar^2)*E*psi8(x2))  ;
Error, invalid types in sum
> diff(diff(psi8(x2)),x,x);
Error, wrong number (or type) of parameters in function diff
> x2<0;
```

$$.5301\ 10^{-10}\ meter < 0$$

```
> 2*me*E/hbar^2=k1^2;
```

$$.3564\ 10^{21} \frac{1}{meter^2} = .3561\ 10^{21} \frac{1}{meter^2}$$

```
> k1:=sqrt(2*me*E/hbar^2);
```

$$k1 := .1888\ 10^{11} \sqrt{\frac{1}{meter^2}}$$

```
> psi8(x2):=exp(1*I*k1*x2);
```

$$\psi 8(.5301\ 10^{-10}\ me\ \ \mathbf{e}^{\left(1.001\ I \sqrt{\frac{1}{meter^2}}\ meter\right)}$$

```
> diff(diff(psi8(x2),x2),x2)+k1^2*psi8(x2) = 0;
>
Error, wrong number (or type) of parameters in function diff
```

> $R0 := \mathrm{dsolve}\left(\left(\frac{\partial}{\partial x2}\left(\frac{\partial}{\partial x2}\psi 8(x2)\right)\right)+\frac{2\, me\, E\, \psi 8(x2)}{hbar^2}=0, \{\psi 8(x2)\}\right)$

```
Error, wrong number (or type) of parameters in function diff
> E:=me*c^2*alpha^2/2;
```

$$E := .2177\ 10^{-17}\ \frac{meter^2\ kg}{second^2}$$

```
> x2:=rbohr;
```

$$x2 := .5301\ 10^{-10}\ meter$$

```
> psi8(x2):=exp(1*I*k1*1);
```

$$\psi 8(.5301\ 10^{-10}\ meter) := \mathbf{e}^{\left(.1888\ 10^{11}\ I\sqrt{\frac{1}{meter^2}}\right)}$$

```
> evalf(I);
```

$$1.\ I$$

```
> diff((diff(psi8(1),x,x))+k1^2*psi8(1));
Error, wrong number (or type) of parameters in function diff
>
>
> ?
```