

(* Commentary *)

(* <http://reference.wolfram.com/language/> *)

(* help F1*)

In[1]:=

(* palettes *)

π

(* Pi → ESC p ESC or Pi *)

(* Arrow → -> *)

Out[1]= π

(* Infinity accuracy *)

Sin[1]

Sin[1]

Sin[1] // N

0.841471

N[Sin[1], 100]

N[Sin[1]]

0.841470984807896506652502321630298999622563060798371065672751709991910404391239668.
9486397435430526959

0.841471

```

Sin[1]
Sin[1.]
Sin[1]
0.841471

```

```

2 / 3

$$\frac{2}{3}$$

2 / 3.
0.666667

```

```

(* case sensitivity *)
a = 4;
a * a
a * A
A * A

```

Out[2]= 4

Out[3]= 16

Out[4]= 4 A

Out[5]= A^2

```

In[18]:= (* colors *)
sin[1.] * Sin[1.]

```

Out[18]= 0.841471 sin[1.]

```

aa * aa
aa^2

```

```

In[19]:= Sin[]
f[t_] := t^2
Table[z, {z, 2, 7, 3}]

```

Sin::argx : Sin called with 0 arguments; 1 argument is expected. >>

Out[19]= Sin[]

Out[21]= {2, 5}

(*

";" at the end of line → the result will not be displayed,
but will be calculated

eg. factorial*)

rob1 = 1000!

```
402 387 260 077 093 773 543 702 433 923 003 985 719 374 864 210 714 632 543 799 910 429 938 512 398 \
629 020 592 044 208 486 969 404 800 479 988 610 197 196 058 631 666 872 994 808 558 901 323 829 \
669 944 590 997 424 504 087 073 759 918 823 627 727 188 732 519 779 505 950 995 276 120 874 975 \
462 497 043 601 418 278 094 646 496 291 056 393 887 437 886 487 337 119 181 045 825 783 647 849 \
977 012 476 632 889 835 955 735 432 513 185 323 958 463 075 557 409 114 262 417 474 349 347 553 \
428 646 576 611 667 797 396 668 820 291 207 379 143 853 719 588 249 808 126 867 838 374 559 731 \
746 136 085 379 534 524 221 586 593 201 928 090 878 297 308 431 392 844 403 281 231 558 611 036 \
976 801 357 304 216 168 747 609 675 871 348 312 025 478 589 320 767 169 132 448 426 236 131 412 \
508 780 208 000 261 683 151 027 341 827 977 704 784 635 868 170 164 365 024 153 691 398 281 264 \
810 213 092 761 244 896 359 928 705 114 964 975 419 909 342 221 566 832 572 080 821 333 186 116 \
811 553 615 836 546 984 046 708 975 602 900 950 537 616 475 847 728 421 889 679 646 244 945 160 \
765 353 408 198 901 385 442 487 984 959 953 319 101 723 355 556 602 139 450 399 736 280 750 137 \
837 615 307 127 761 926 849 034 352 625 200 015 888 535 147 331 611 702 103 968 175 921 510 907 \
788 019 393 178 114 194 545 257 223 865 541 461 062 892 187 960 223 838 971 476 088 506 276 862 \
967 146 674 697 562 911 234 082 439 208 160 153 780 889 893 964 518 263 243 671 616 762 179 168 \
909 779 911 903 754 031 274 622 289 988 005 195 444 414 282 012 187 361 745 992 642 956 581 746 \
628 302 955 570 299 024 324 153 181 617 210 465 832 036 786 906 117 260 158 783 520 751 516 284 \
225 540 265 170 483 304 226 143 974 286 933 061 690 897 968 482 590 125 458 327 168 226 458 066 \
526 769 958 652 682 272 807 075 781 391 858 178 889 652 208 164 348 344 825 993 266 043 367 660 \
176 999 612 831 860 788 386 150 279 465 955 131 156 552 036 093 988 180 612 138 558 600 301 435 \
694 527 224 206 344 631 797 460 594 682 573 103 790 084 024 432 438 465 657 245 014 402 821 885 \
252 470 935 190 620 929 023 136 493 273 497 565 513 958 720 559 654 228 749 774 011 413 346 962 \
715 422 845 862 377 387 538 230 483 865 688 976 461 927 383 814 900 140 767 310 446 640 259 899 \
490 222 221 765 904 339 901 886 018 566 526 485 061 799 702 356 193 897 017 860 040 811 889 729 \
918 311 021 171 229 845 901 641 921 068 884 387 121 855 646 124 960 798 722 908 519 296 819 372 \
388 642 614 839 657 382 291 123 125 024 186 649 353 143 970 137 428 531 926 649 875 337 218 940 \
694 281 434 118 520 158 014 123 344 828 015 051 399 694 290 153 483 077 644 569 099 073 152 433 \
278 288 269 864 602 789 864 321 139 083 506 217 095 002 597 389 863 554 277 196 742 822 248 757 \
586 765 752 344 220 207 573 630 569 498 825 087 968 928 162 753 848 863 396 909 959 826 280 956 \
121 450 994 871 701 244 516 461 260 379 029 309 120 889 086 942 028 510 640 182 154 399 457 156 \
805 941 872 748 998 094 254 742 173 582 401 063 677 404 595 741 785 160 829 230 135 358 081 840 \
096 996 372 524 230 560 855 903 700 624 271 243 416 909 004 153 690 105 933 983 835 777 939 410 \
970 027 753 472 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 \
000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 \
000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 \
000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000 000
```

(* semicolon *)

rob2 = 1000!;

rob2^(1 / 10000.)

1.80618

```
(* use
  MatrixForm
  TraditionalForm
  ScientificForm
  ONLY ! for graphical output
*)
```

```
TraditionalForm[Sin[1]]
```

```
sin(1)
```

```
In[38]:=
```

```
TraditionalForm[Sin[1]]^2.
N[TraditionalForm[Sin[1]]^2.]
```

```
Out[38]= sin(1)^2.
```

```
Out[39]= 0.841471^2.
```

```
Sin[1]^2.
```

```
0.708073
```

```
TraditionalForm[EulerGamma]
```

```
 $\gamma$ 
```

```
a1 = ScientificForm[{123 450 000.0, 0.000012345, 123.45}]
```

```
a1^2
```

```
a2 = {123 450 000.0, 0.000012345, 123.45}
```

```
a2^2
```

```
(* built-in constants *)
```

```
 $\pi$  // N
```

```
e // N
```

```
GoldenRatio // N
```

```
3.14159
```

```
2.71828
```

```
1.61803
```

```
(* built-in functions *)
```

```
(* always starts with capital letter *)
```

```
a + b
```

```
Plus[a, b]
```

```
{11, 22, 33}
```

```
{11, 22, 33}
```

```

a 2
a * 2
Times[a, 2]

```

```
{2, 4, 6}
```

```
{2, 4, 6}
```

```
{2, 4, 6}
```

```
2 a
```

```
a2
```

```
{2, 4, 6}
```

```
a2
```

```
Sin[2  $\pi$ ]
```

```
0
```

```
Log[e]
```

```
1
```

```
In[40]:=
```

```
Sqrt[36]
```

```
Out[40]= 6
```

```
In[41]:= (* the last Out *)
```

```
%
```

```
Out[41]= 6
```

```
In[46]:= %27
```

```
Out[46]= 0.8414712.
```

```

(*      ( )
  parentheses for grouping *)

```

```

(*      [ ]
  square brackets for functions *)

```

```

(*      { }
  curly braces for lists *)

```

```

(*      [[ ]]
  double brackets for indexing (Part[v,iD]  *)

```

```
a = {1, 2, 3}
```

```
b = {10, 20, 30}
```

```
{1, 2, 3}
```

```
{10, 20, 30}
```

```
a + b
```

```
{11, 22, 33}
```

```

b + 2 * a
{12, 24, 36}

Sin[a] // N
{0.841471, 0.909297, 0.14112}

a * b
{10, 40, 90}

a
{1, 2, 3}

a[[2]]
2

(b + 2 * a)[[1]]
b + 2 * a[[1]]
12
{12, 22, 32}

(Sin[a] // N)[[1]]
0.841471

c = {a, b, a + b}
{{1, 2, 3}, {10, 20, 30}, {11, 22, 33}}

c // TraditionalForm
c // MatrixForm

$$\begin{pmatrix} 1 & 2 & 3 \\ 10 & 20 & 30 \\ 11 & 22 & 33 \end{pmatrix}$$


$$\begin{pmatrix} 1 & 2 & 3 \\ 10 & 20 & 30 \\ 11 & 22 & 33 \end{pmatrix}$$


c2 = {2 a, 3 b, a + b};
MatrixForm[%]

$$\begin{pmatrix} 2 & 4 & 6 \\ 30 & 60 & 90 \\ 11 & 22 & 33 \end{pmatrix}$$


c2
{{2, 4, 6}, {30, 60, 90}, {11, 22, 33}}

c2[[1]]
{2, 4, 6}

c2[[1, 2]]
4

c2[[2, 1]]
30

c2[[All, -1]]
{6, 90, 33}

```

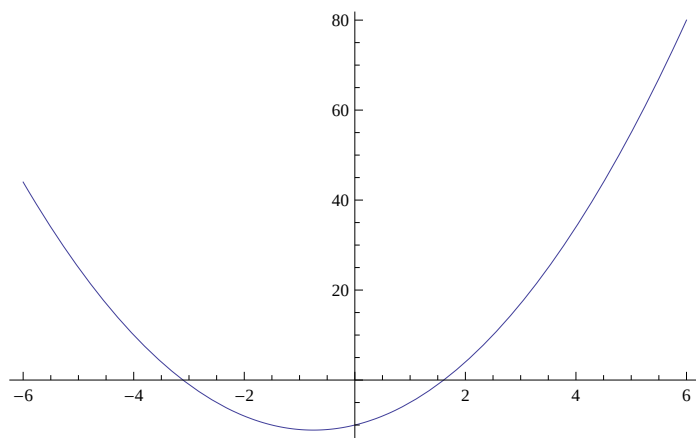
(* functions *)

f[x_] := 2 x^2 + 3 x - 10

f[y]

$-10 + 3 y + 2 y^2$

Plot[f[s], {s, -6, 6}]

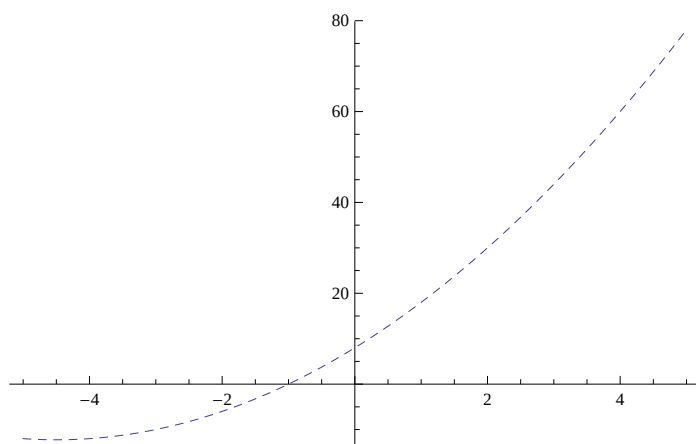


f2[x_, y_] := 2 x^2 + 3 x * y - 10 + y^2

f2[2, 4]

38

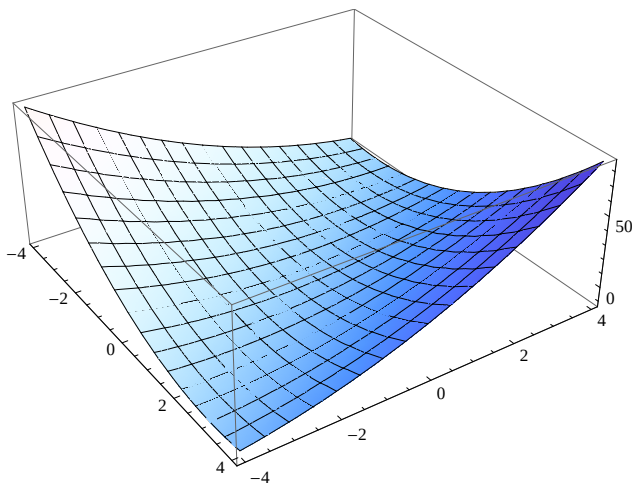
Plot[f2[3, s], {s, -5, 5}, PlotStyle -> {Dashed}]



Options[Plot3D]

```
{AlignmentPoint → Center, AspectRatio → Automatic, Axes → True, AxesEdge → Automatic,
AxesLabel → None, AxesOrigin → Automatic, AxesStyle → {}, Background → None,
BaselinePosition → Automatic, BaseStyle → {}, BoundaryStyle → GrayLevel[0],
Boxed → True, BoxRatios → {1, 1, 0.4}, BoxStyle → {}, ClippingStyle → Automatic,
ColorFunction → Automatic, ColorFunctionScaling → True, ColorOutput → Automatic,
ContentSelectable → Automatic, ControllerLinking → Automatic,
ControllerMethod → Automatic, ControllerPath → Automatic,
CoordinatesToolOptions → Automatic, DisplayFunction → $DisplayFunction,
Epilog → {}, Evaluated → Automatic, EvaluationMonitor → None, Exclusions → Automatic,
ExclusionsStyle → None, FaceGrids → None, FaceGridsStyle → {}, Filling → None,
FillingStyle → Opacity[0.5], FormatType → TraditionalForm, ImageMargins → 0.,
ImagePadding → All, ImageSize → Automatic, LabelStyle → {}, Lighting → Automatic,
MaxRecursion → Automatic, Mesh → Automatic, MeshFunctions → {#1 &, #2 &},
MeshShading → None, MeshStyle → Automatic, Method → Automatic,
NormalsFunction → Automatic, PerformanceGoal → $PerformanceGoal,
PlotLabel → None, PlotPoints → Automatic, PlotRange → {Full, Full, Automatic},
PlotRangePadding → Automatic, PlotRegion → Automatic, PlotStyle → Automatic,
PreserveImageOptions → Automatic, Prolog → {}, RegionFunction → (True &),
RotationAction → Fit, SphericalRegion → False, Ticks → Automatic, TicksStyle → {},
ViewAngle → Automatic, ViewCenter → Automatic, ViewMatrix → Automatic,
ViewPoint → {1.3, -2.4, 2.}, ViewRange → All, ViewVector → Automatic,
ViewVertical → {0, 0, 1}, WorkingPrecision → MachinePrecision}
```

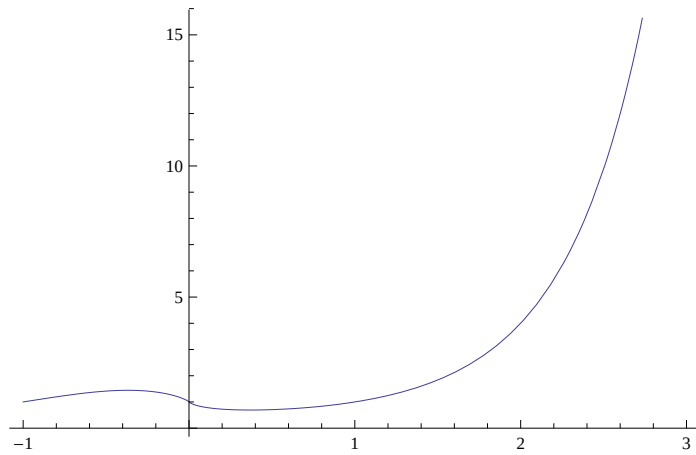
Plot3D[f2[x, y], {x, -4, 4}, {y, -4, 4}]



```

h[x_] := Abs[x]^x
Plot[h[x], {x, -1, 3}]
h[-2.1]
h[f[h[x]]]

```



```
0.210542
```

```
Abs[-10 + 3 Abs[x]^x + 2 Abs[x]^2 x]^(-10 + 3 Abs[x]^x + 2 Abs[x]^2 x)
```

```
f[2 (x + 1) (x - 1)]
```

```
-10 + 6 (-1 + x) (1 + x) + 8 (-1 + x)^2 (1 + x)^2
```

```
f[f[f[f[x]]]]
```

```
Expand[f[f[f[f[x]]]]]
```

```

-10 + 3 (-10 + 3 (-10 + 3 (-10 + 3 x + 2 x^2) + 2 (-10 + 3 x + 2 x^2)^2) +
      2 (-10 + 3 (-10 + 3 x + 2 x^2) + 2 (-10 + 3 x + 2 x^2)^2)^2) +
      2 (-10 + 3 (-10 + 3 (-10 + 3 x + 2 x^2) + 2 (-10 + 3 x + 2 x^2)^2) +
      2 (-10 + 3 (-10 + 3 x + 2 x^2) + 2 (-10 + 3 x + 2 x^2)^2)^2)^2
5 339 732 800 - 14 751 585 759 x + 7 839 051 280 x^2 + 11 573 400 240 x^3 -
11 088 734 640 x^4 - 3 894 257 088 x^5 + 5 629 578 048 x^6 + 869 849 856 x^7 -
1 601 601 024 x^8 - 201 758 208 x^9 + 275 442 688 x^10 + 45 821 952 x^11 -
26 218 496 x^12 - 6 537 216 x^13 + 851 968 x^14 + 393 216 x^15 + 32 768 x^16

```

```
z[x_] := f[f[f[f[x]]]]
```

```
Expand[z[α]]
```

```

5 339 732 800 - 14 751 585 759 α + 7 839 051 280 α^2 + 11 573 400 240 α^3 -
11 088 734 640 α^4 - 3 894 257 088 α^5 + 5 629 578 048 α^6 + 869 849 856 α^7 -
1 601 601 024 α^8 - 201 758 208 α^9 + 275 442 688 α^10 + 45 821 952 α^11 -
26 218 496 α^12 - 6 537 216 α^13 + 851 968 α^14 + 393 216 α^15 + 32 768 α^16

```

```
(*Solving equations *)
```

```
Solve[-10 + 3 g + 2 g^2 == 0, g]
```

```
{ {g -> 1/4 (-3 - Sqrt[89])}, {g -> 1/4 (-3 + Sqrt[89])} }
```

```
Solve[-10 + 3 g + 2 g^2 == 0., g]
```

```
{ {g -> -3.1085}, {g -> 1.6085} }
```

```
NSolve[-10 + 3 g + 2 g^2 == 0, g]
```

```
{{g -> -3.1085}, {g -> 1.6085}}
```

```
Solve[(-10 + 3 g + 2 g^2)^(3/2) == 2 g^4, g]
```

```
{{g -> Root[1000 - 900 #1 - 330 #1^2 + 333 #1^3 + 66 #1^4 - 36 #1^5 - 8 #1^6 + 4 #1^8 &, 3]},  
{g -> Root[1000 - 900 #1 - 330 #1^2 + 333 #1^3 + 66 #1^4 - 36 #1^5 - 8 #1^6 + 4 #1^8 &, 4]},  
{g -> Root[1000 - 900 #1 - 330 #1^2 + 333 #1^3 + 66 #1^4 - 36 #1^5 - 8 #1^6 + 4 #1^8 &, 7]},  
{g -> Root[1000 - 900 #1 - 330 #1^2 + 333 #1^3 + 66 #1^4 - 36 #1^5 - 8 #1^6 + 4 #1^8 &, 8]}}
```

```
Solve[(-10. + 3 g + 2 g^2)^(3/2) == 2 g^4, g]
```

```
{{g -> -1.23214 - 2.42678 i}, {g -> -1.23214 + 2.42678 i},  
{g -> 1.80598 - 1.32238 i}, {g -> 1.80598 + 1.32238 i}}
```

```
NSolve[(-10. + 3 g + 2 g^2)^(3/2) == 2 g^4, g]
```

```
{{g -> -1.23214 + 2.42678 i}, {g -> -1.23214 - 2.42678 i},  
{g -> 1.80598 + 1.32238 i}, {g -> 1.80598 - 1.32238 i}}
```

```
Solve[{3 x + 4 y == 10, 2 x - y == 3}, {x, y}]
```

```
{{x -> 2, y -> 1}}
```

```
eq1 = 3 x + 4 y == 20;
```

```
eq2 = 2 x - y == 6;
```

```
sol1 = Solve[{eq1, eq2}, {x, y}]
```

```
{{x -> 4, y -> 2}}
```

```
{eq1, eq2} /. sol1
```

```
{3 x + 4 y == 10, 2 x - y == 3} /. {{x -> 2, y -> 1}}
```

```
{{True, True}}
```

```
{{True, True}}
```

```
eqofmotion1 = m * q''[t] + k * q[t] == 0
```

```
k q[t] + m q''[t] == 0
```

```
solut1 = DSolve[{eqofmotion1, q[0] == q0, q'[0] == qpo}, q[t], t]
```

```
{{q[t] -> 1/sqrt(k) (sqrt(k) q0 Cos[sqrt(k) t/sqrt(m)] + sqrt(m) qpo Sin[sqrt(k) t/sqrt(m)])}}
```

```
solut1 // TraditionalForm
```

```
{{q(t) -> 1/sqrt(k) (sqrt(k) q0 cos(sqrt(k) t/sqrt(m)) + sqrt(m) qpo sin(sqrt(k) t/sqrt(m)))}}
```

```
DSolve[eqofmotion1, q[t], t]
```

```
{{q[t] -> C[1] Cos[sqrt(k) t/sqrt(m)] + C[2] Sin[sqrt(k) t/sqrt(m)]}}
```

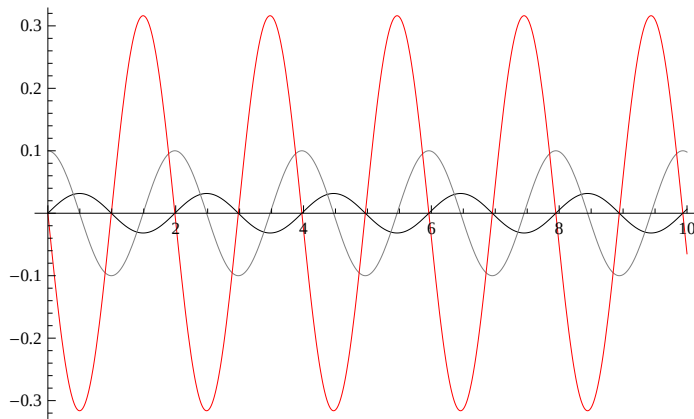
```
q1[t_] = solut1[[1, 1, 2]]
```

```
1/sqrt(k) (sqrt(k) q0 Cos[sqrt(k) t/sqrt(m)] + sqrt(m) qpo Sin[sqrt(k) t/sqrt(m)])
```

```

q1[0]
q0
q1'[0]
qpo
Block[{m = 1000, k = 10000, q0 = 0.0, qpo = 0.1},
  Plot[{q1[t], q1'[t], q1''[t]}, {t, 0, 10}, PlotStyle -> {Black, Gray, Red}]

```



m

m

c

```
{ {1, 2, 3}, {10, 20, 30}, {11, 22, 33} }
```

```
Clear[c]
```

```
eqofmotion2 = m * q''[t] + c * q'[t] + k * q[t] == 0
```

```
k q[t] + c q'[t] + m q''[t] == 0
```

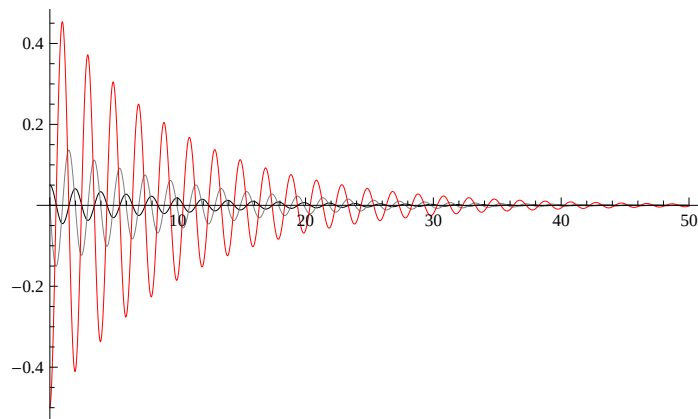
```
solut2 = DSolve[{eqofmotion2, q[0] == q0, q'[0] == qpo}, q[t], t]
```

$$\left\{ \left\{ q[t] \rightarrow \frac{1}{2\sqrt{c^2 - 4km}} \left(-c e^{\frac{(-c - \sqrt{c^2 - 4km})t}{2m}} q_0 + c e^{\frac{(-c + \sqrt{c^2 - 4km})t}{2m}} q_0 + e^{\frac{(-c - \sqrt{c^2 - 4km})t}{2m}} \sqrt{c^2 - 4km} q_0 + e^{\frac{(-c + \sqrt{c^2 - 4km})t}{2m}} \sqrt{c^2 - 4km} q_0 - 2 e^{\frac{(-c - \sqrt{c^2 - 4km})t}{2m}} m q_{po} + 2 e^{\frac{(-c + \sqrt{c^2 - 4km})t}{2m}} m q_{po} \right) \right\} \right\}$$

```
q2[t_] = solut2[[1, 1, 2]]
```

$$\frac{1}{2\sqrt{c^2 - 4km}} \left(-c e^{\frac{(-c - \sqrt{c^2 - 4km})t}{2m}} q_0 + c e^{\frac{(-c + \sqrt{c^2 - 4km})t}{2m}} q_0 + e^{\frac{(-c - \sqrt{c^2 - 4km})t}{2m}} \sqrt{c^2 - 4km} q_0 + e^{\frac{(-c + \sqrt{c^2 - 4km})t}{2m}} \sqrt{c^2 - 4km} q_0 - 2 e^{\frac{(-c - \sqrt{c^2 - 4km})t}{2m}} m q_{po} + 2 e^{\frac{(-c + \sqrt{c^2 - 4km})t}{2m}} m q_{po} \right)$$

```
Block[{m = 1000, k = 10000, c = 200, q0 = 0.05, qpo = 0.0}, Plot[{q2[t], q2'[t], q2''[t]},
  {t, 0, 50}, PlotStyle -> {Black, Gray, Red}, PlotRange -> All]]
```



```
eqofmotion3 = m * q''[t] + c * q'[t] + k * q[t] == F * Sin[p * t]
```

```
k q[t] + c q'[t] + m q''[t] == F Sin[p t]
```

```
solut3 = DSolve[{eqofmotion3, q[0] == 0, q'[0] == 0}, q[t], t];
```

```
q3[t_] = solut3[[1, 1, 2]];
```

```
Block[{m = 100, k = 10000, c = 200, p = 50, F = 100}, Plot[q3[t], {t, 0, 6.0}]]
```

