•**20** The position of a particle moving along an x axis is given by $x = 12t^2 - 2t^3$, where x is in meters and t is in seconds. Determine (a) the position, (b) the velocity, and (c) the acceleration of the particle at $t = 3.0$ s. (d) What is the maximum positive coordinate reached by the particle and (e) at what time is it reached? (f) What is the maximum positive velocity reached by the particle and (g) at what time is it reached? (h) What is the acceleration of the particle at the instant the particle is not moving (other than at $t = 0$)? (i) Determine the average velocity of the particle between $t = 0$ and $t = 3$ s.

Chapter 2 example of x, v, and a.

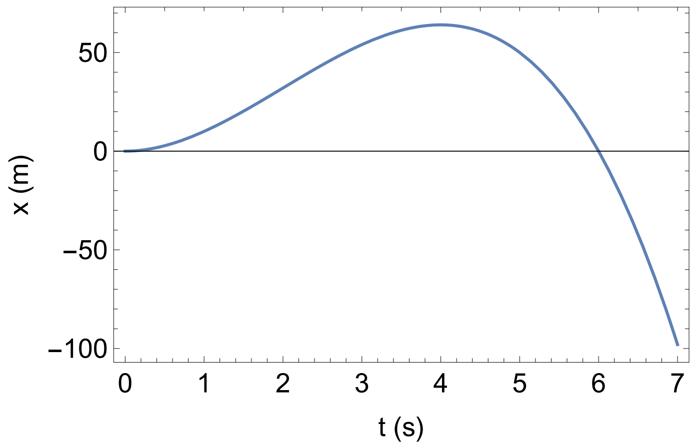
Given the following function for x[t]:

In[29]:=
```
x[t_] := 12 t^2 - 2 t^3
```

For all that follows, it will be convenient to have a graph of x vs. t in mind.

In[30]:=
```
Plot[x[t], {t, 0, 7},
 Frame → True, FrameLabel → {"t (s)", "x (m)"}, LabelStyle → Larger]
```

Out[30]=



a, b, and c. Position, velocity, and acceleration at t = 3.0 s.

In[31]:=
```
v[t_] := x'[t]
v[t]
```

Out[32]= $24\,t - 6\,t^2$

In[33]:=
```
a[t_] := v'[t]
a[t]
```

Out[34]= $24 - 12\,t$

In[35]:=
```
x[3]
v[3]
a[3]
```

Out[35]= 54

Out[36]= 18

Out[37]= -12

d and e: Maximum x, and when is it reached?

Mathematica can do it directly:

In[38]:=
```
FindMaximum[x[t], t]
```
Out[38]=
```
{64., {t → 4.}}
```

Or, you could use the fact that v[t] == 0 when x[t] is a maximum, solve for that t, and then plug it in to x[t].

In[39]:=
```
Solve[v[t] == 0, t]
```
Out[39]=
```
{{t → 0}, {t → 4}}
```

In[40]:=
```
x[4]
```
Out[40]=
```
64
```

f and g: Maximum v and when is it reached?

Again, you can do it directly:

In[41]:=
```
FindMaximum[v[t], t]
```
Out[41]=
```
{24., {t → 2.}}
```

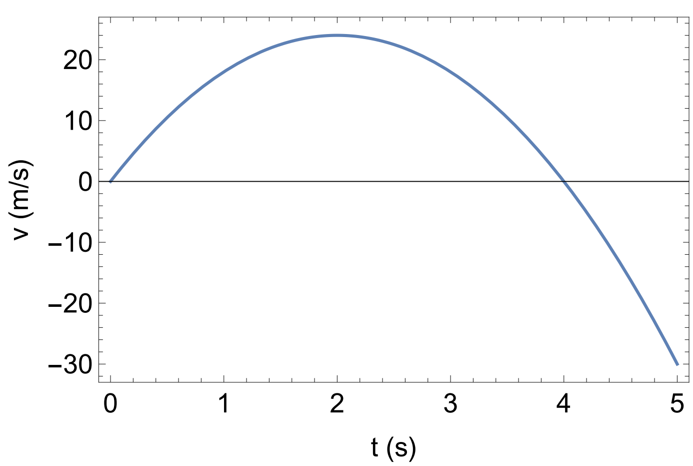
Or you can use the face that a[t] == 0 when v[t] is a maximum, solve for that t, and then plug it in to v[t].

In[42]:=
```
Solve[a[t] == 0, t]
```
Out[42]=
```
{{t → 2}}
```

In[43]:=
```
v[2]
```
Out[43]=
```
24
```

For reference, here is a plot of v[t].

In[44]:=
```
Plot[v[t], {t, 0, 5},
 Frame → True, FrameLabel → {"t (s)", "v (m/s)"}, LabelStyle → Larger]
```
Out[44]=



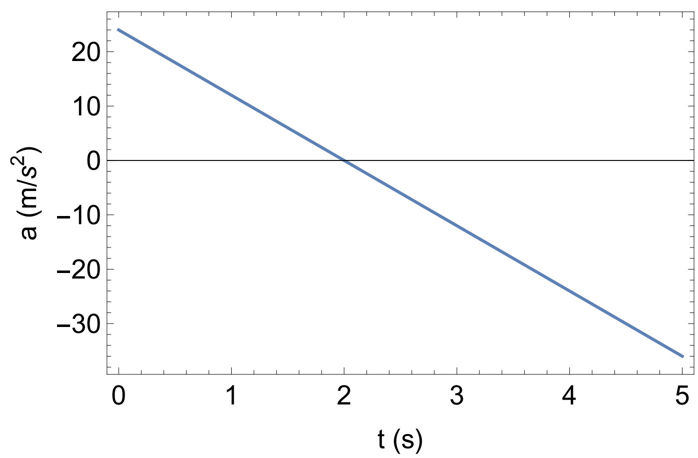
h: Acceleration when v[t] == 0?

In[45]:=
```
a[t]
```
Out[45]= $24 - 12\,t$

In[46]:=
```
Solve[v[t] == 0, t]
```
Out[46]= {{t → 0}, {t → 4}}

In[47]:=
```
a[4]
```
Out[47]= -24

In[48]:=
```
Plot[a[t], {t, 0, 5},
 Frame → True, FrameLabel → {"t (s)", "a (m/s²)"}, LabelStyle → Larger]
```
Out[48]=



i: Average velocity from 0 to 3 s.

In[49]:=
```
vav = (x[3] - x[0]) / (3 - 0)
```
Out[49]= 18