

Chapter 10 / **Example 21****Application of differentiation to kinematics**

The height (m) of a rocket projected vertically into the air until it returns to the ground is represented by the function $h(t) = -0.11t^2 + 1.32t + 1.5$, $t \geq 0$ where t is the number of seconds after the rocket was launched.

- State the height at which the rocket was launched.
- Find the maximum height reached by the rocket.
- Calculate the velocity of the rocket at $t = 7.5$ s and state whether it is ascending or descending at this time.
- Find the other time at which the rocket is travelling at the same speed as when $t = 7.5$ s

Press **MENU** 5 **GRAPH** to display the equation entry screen.

Type $-0.11x^2 + 1.32x + 1.5$ and press **EXE** to enter the equation as Y1.

Graph Func :Y=
Y1: $-0.11x^2 + 1.32x$ [—]
Y2: [—]
Y3: [—]
Y4: [—]
Y5: [—]
Y6: [—]
[SELECT] [DELETE] [TYPE] [TOOL] [MODIFY] [DRAW]

Choose appropriate axes to show the graph.

Press **SHIFT** **F3** V-WIN.

Set the axes to show $-1 \leq x \leq 14$ and $-2 \leq y \leq 8$ with a scale of 1.

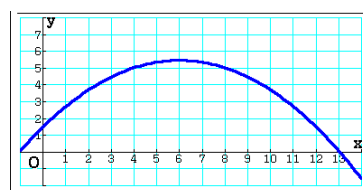
You can leave the other items as they are.

Press **EXIT** when you have finished.

View Window
Xmin : -1
max : 14
scale: 1
dot : 0.03968253
Ymin : -2
max : 8
[INITIAL] [TRIG] [STANDARD] [V-MEM] [SQUARE]

Press **F6** DRAW to display the graph screen.

The GDC now displays the quadratic function $Y1 = -0.11x^2 + 1.32x + 1.5$.



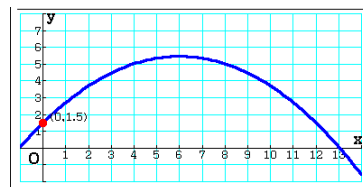
To find the y-intercept press **F5** G-SOLVE and then press **F4** Y-ICEPT

Press **EXE** to display the coordinates.

Press **EXIT** to leave G-Solv mode and **F6** DRAW to display the graph screen again.

The y-intercept is at 0, 1.5 .

The rocket was launched from a height of 1.5 m.



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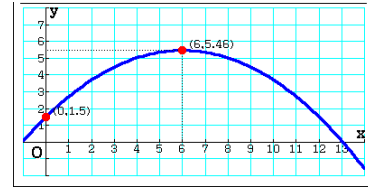
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To find the vertex press **F5** G-SOLVE and then press **F2** MAX
Press **EXE** to display the coordinates.

Press **EXIT** to leave G-Solv mode and **F6** DRAW to display the graph screen again.

The vertex of the quadratic function is at 6, 5.46 .

The maximum height is 5.46 m.



To find the velocity of the rocket with a GDC, use the first derivative.

To display the derivative, press **EXIT** then press **OPTN**, **F2** CALC, **F1** d/dx

The template has spaces for the function and the value that it is evaluated at.

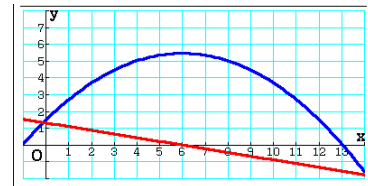
Enter the function Y1 by pressing **F1** Y and typing 1

Type x and press **EXE** .

Graph Func :Y=
Y1=-0.11x²+1.32x [—]
Y2=d/dx(Y1)|_{x=x} [—]
Y3: [—]
Y4: [—]
Y5: [—]
[SELECT] [DELETE] [TYPE] [TOOL] [MODIFY] [DRAW]

Press **F6** DRAW to display the graph screen.

The GDC displays the graph Y1 and its first derivative.



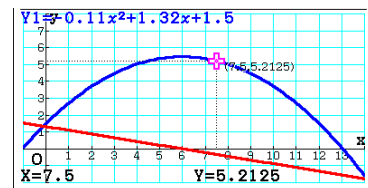
To find the velocity at $t = 7.5$ press **F1** Trace

Type 7.5, the value of the x-coordinate, and press **EXE** .

The point is 7.5, -0.33 .

The velocity is -0.33 ms^{-1} .

Because the velocity is negative, the height is decreasing and so the rocket is descending.



To find another point where $v = +0.33 \text{ ms}^{-1}$ draw the line $y = 0.33$ and find the point of intersection.

Press **EXIT** to display the equation entry screen.

Type 0.33 and press **EXE** to enter the equation as Y3.

Graph Func :Y=
Y1=-0.11x²+1.32x [—]
Y2=d/dx(Y1)|_{x=x} [—]
Y3=0.33 [—]
Y4: [—]
Y5: [—]
[SELECT] [DELETE] [TYPE] [TOOL] [MODIFY] [DRAW]

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Press **F6** DRAW to display the graph screen.

To find the intersection press **F5** G-Solv **F5** Intersect.

Select Y2 and Y3.

Press **EXE** to display the coordinates.

Press **EXIT** to leave G-Solv mode and **F6** DRAW to display the graph screen again.

The GDC displays the intersection of the two straight lines at the point 4.5, 0.33

The rocket has the same speed at $t = 4.5$ s.

