## Answer on Question 72235 - Physics / Mechanics | Relativity

## Question

An experiment rocket designed to land upright falls freely from a height of $2 \times 10^{\wedge} 2 \mathrm{~m}$, starting at rest. At a height of 80 m , the rocket's engines start. And provide constant upward acceleration until the rocket lands. What acceleration is required if the speed on touchdown is to be zero?

Solution. Draw the diagram for this task. Initial height of the rocket is $y_{0}=200 \mathrm{~m}$. Height when the rocket's engines start is $y_{1}=80 \mathrm{~m}$. Height of landing is $y_{2}=0$.


First we find the speed of the rocket just before the engines start, that is, for $y=y_{1}$. For this we use the formula for $v^{2}$ at constant acceleration

$$
v_{1}^{2}=v_{0}^{2}+2 g\left(y_{0}-y_{1}\right)
$$

where $v_{0}$ is the initial speed of the rocket, $v_{1}$ is the speed of the rocket at $y=y_{1}, g=9.80 \mathrm{~m} / \mathrm{c}^{2}$ is the acceleration due to gravity, $\left(y_{0}-y_{1}\right)$ is the distance that the rocket fell freely before the engines start. Since a rocket start at rest then $v_{0}=0$ and we get

$$
v_{1}^{2}=2 g\left(y_{0}-y_{1}\right)
$$

Now we find the required acceleration $a$ and use the same formula changing the subscripts

$$
v_{2}^{2}=v_{1}^{2}+2 a\left(y_{1}-y_{2}\right)
$$

Here $v_{1}$ is the initial speed before deceleration, $v_{2}=0$ is the speed on touchdown, $\left(y_{1}-y_{2}\right)$ is the distance that the rocket fell with deceleration. We get

$$
a=-\frac{v_{1}^{2}}{2\left(y_{1}-y_{2}\right)}
$$

Substitution $v_{1}^{2}=2 g\left(y_{0}-y_{1}\right)$ yields

$$
a=-\frac{2 g\left(y_{0}-y_{1}\right)}{2\left(y_{1}-y_{2}\right)}=-g \frac{\left(y_{0}-y_{1}\right)}{\left(y_{1}-y_{2}\right)}
$$

Plugging $y_{0}=200 \mathrm{~m}, y_{1}=80 \mathrm{~m}, y_{2}=0$ and $g=9.80 \mathrm{~m} / \mathrm{c}^{2}$ we get

$$
a=-9.80 \frac{200-80}{80-0}=-9.80 \cdot 1.5=-14.7 \mathrm{~m} / \mathrm{c}^{2}
$$

The minus sign of acceleration shows that the rocket is moving with deceleration
Answer: required acceleration is $a=-14.7 \mathrm{~m} / \mathrm{c}^{2}$.

