Newton gravitational potential:

$$V = V_N(r) = \frac{h^2}{r^2} - \frac{2m}{r}\ . \tag{1}$$

Schwarzschild gravitational potential:

$$V = V_{GR}(r) = \frac{h^2}{r^2} - \frac{2m}{r} - \frac{2m\,h^2}{r^3} = V_N(r) - \frac{2m\,h^2}{r^3}\ . \tag{2}$$

Using gravitational units $G = c = 1$ and as mass unit [sm], the central (solar) mass m:

$$V_N(r) = \frac{h^2}{r^2} - \frac{2}{r} \quad \text{and} \quad V_{GR}(r) = \frac{h^2}{r^2} - \frac{2}{r} - \frac{2h^2}{r^3}\ . \tag{3}$$

Here h is the specific angular moment and the number 2 carries the dimsion of a mass. In these units we have $h \approx 10,000$ for the orbit of the earth about the sun (not included in the following pictures).

Consider a point mass at the center.

Small h: Barrier against falling into the black hole disappears.

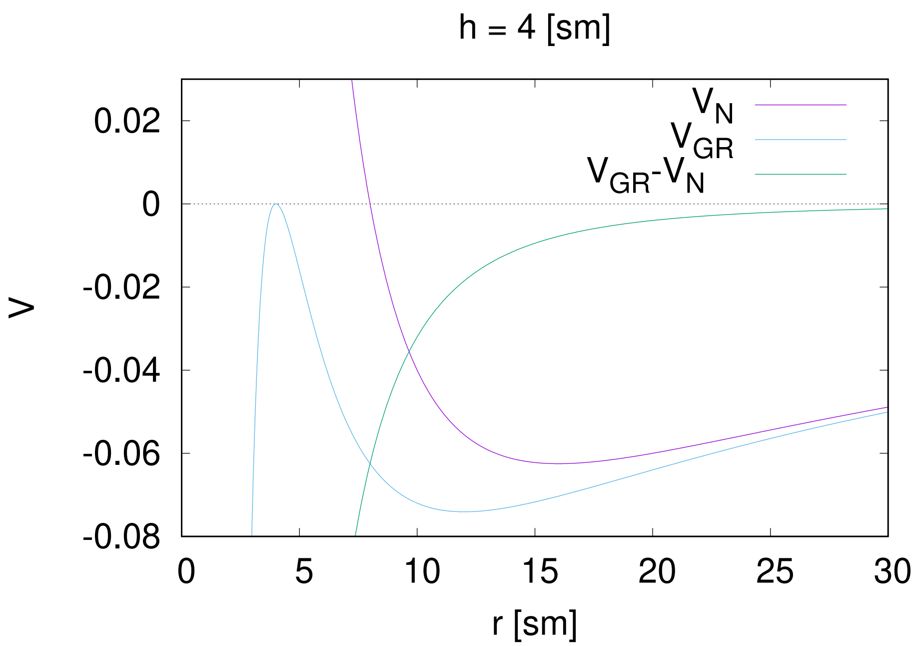
Large enough, increasing h: Barrier againt falling into the black hole increases.

The maximum and minimum of the $V_{GR}(r)$ potential are at

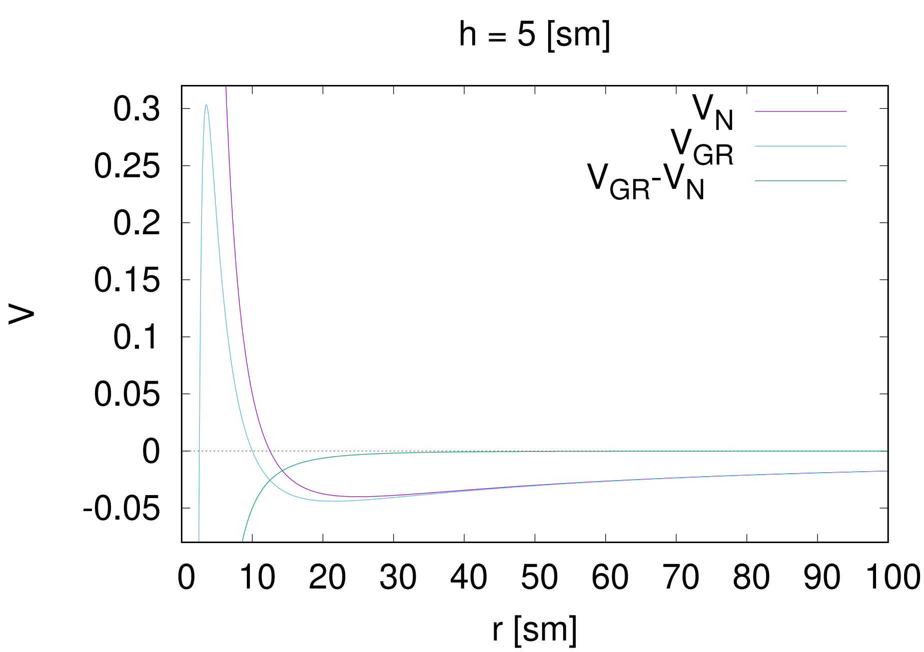
$$r_\pm = \frac{h^2}{2} \pm \sqrt{\left(\frac{h^2}{2}\right)^2 - 3\,h^2}\,, \tag{4}$$

where $V_{\rm min} = V_{GR}(r_+)$ and $V_{\rm max} = V_{GR}(r_-)$. From Eq. (4) it follows that there are no extrema for $h^2 \leq 12$.

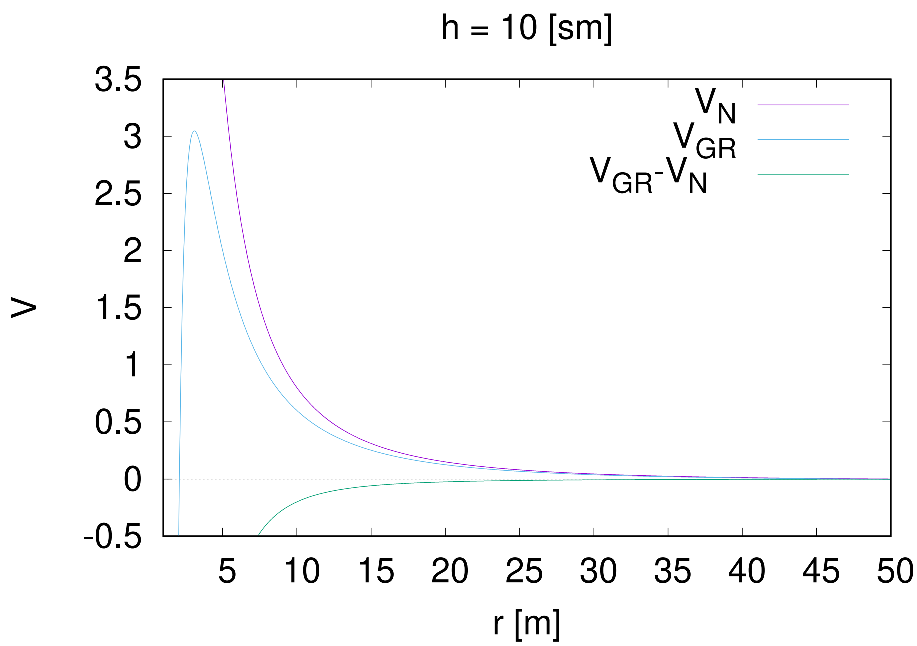
Increasing $h \geq 4$



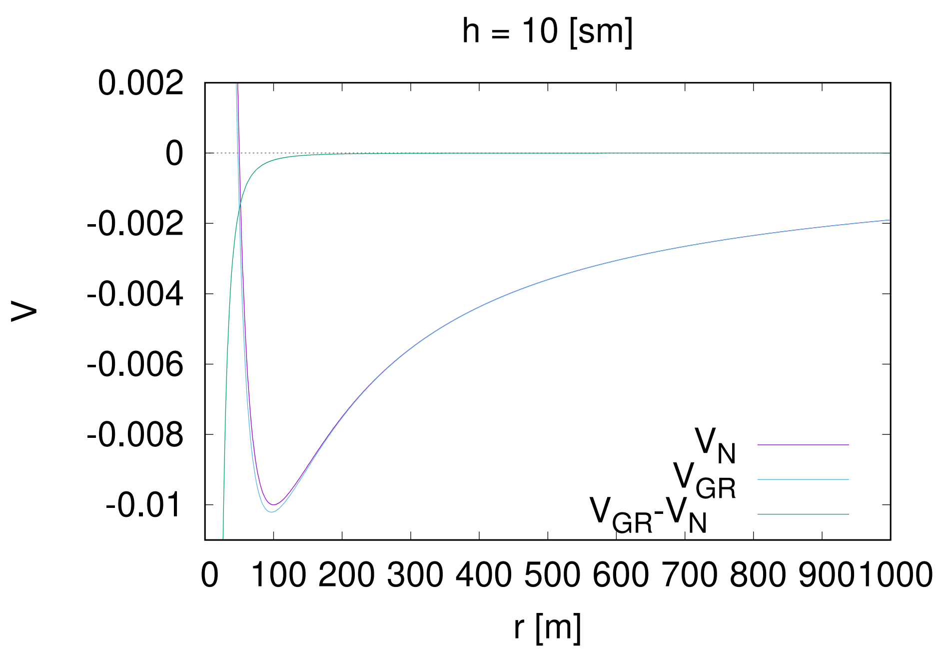
Gravitational Potential.



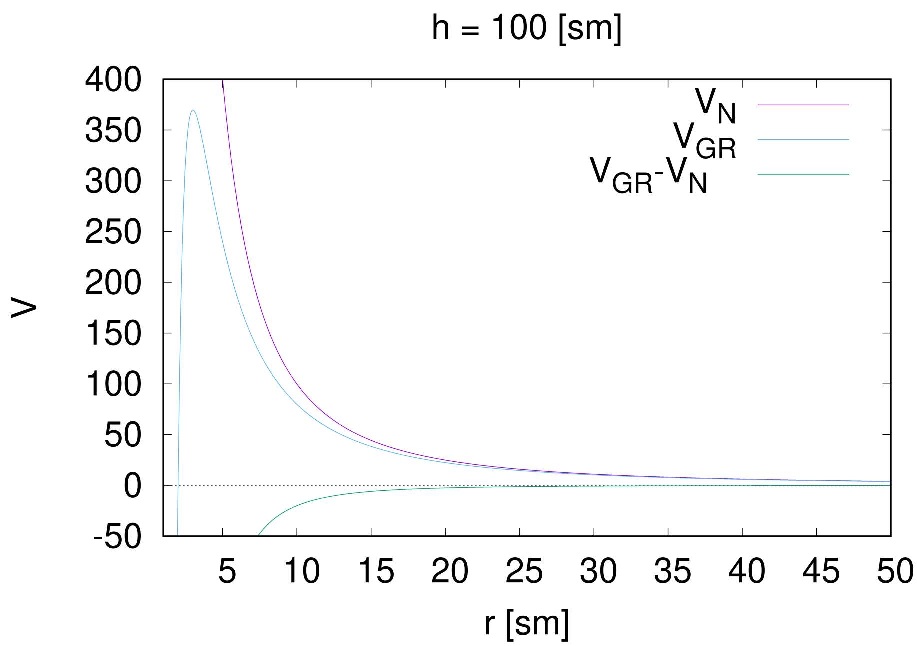
Gravitatonal Potential.



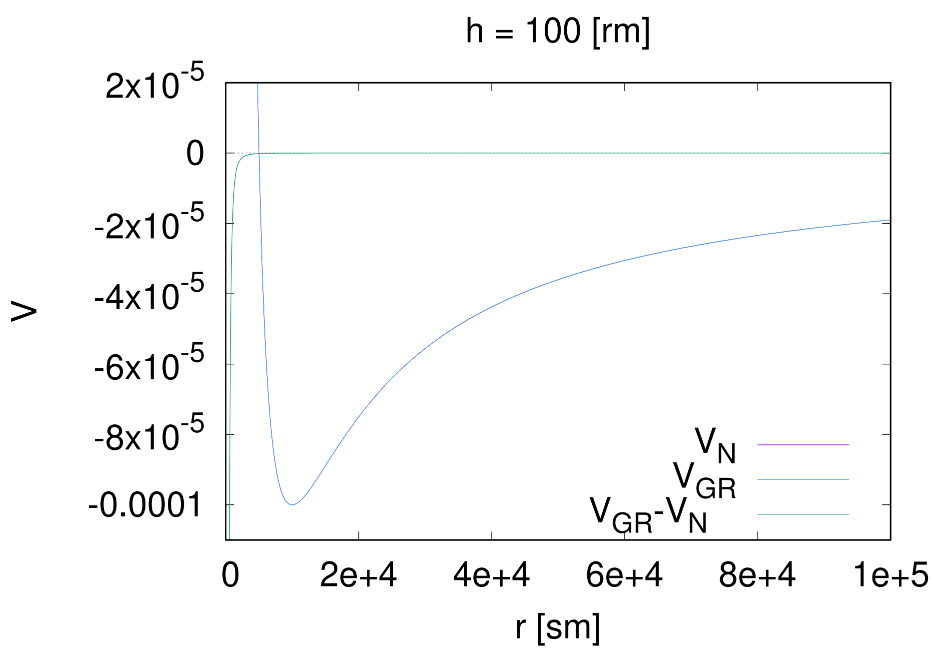
Schwarzschild Singularity.



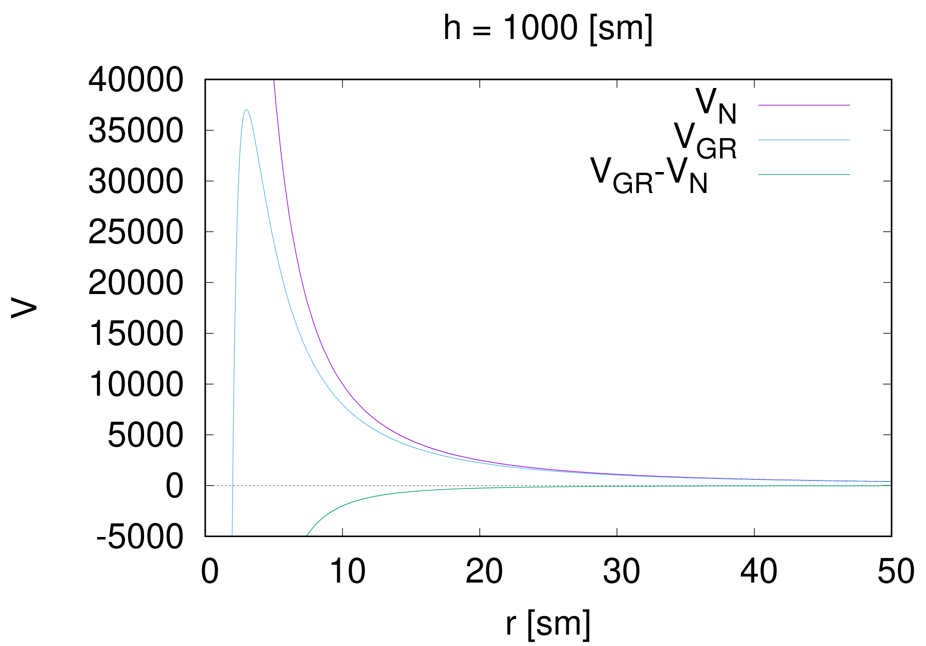
Newton Potential.



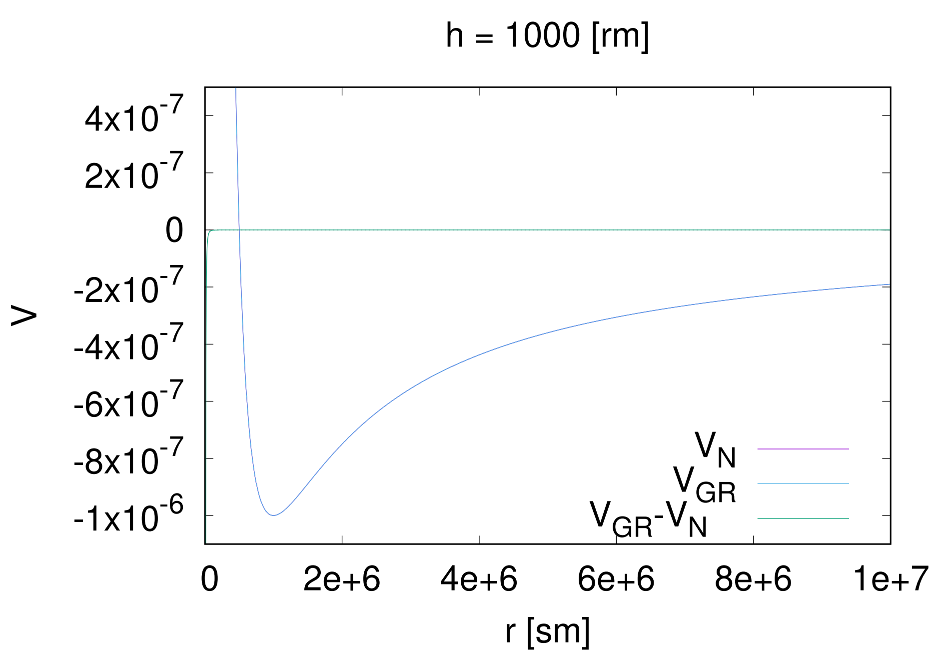
Schwarzschild Singularity.



Newton Potential.

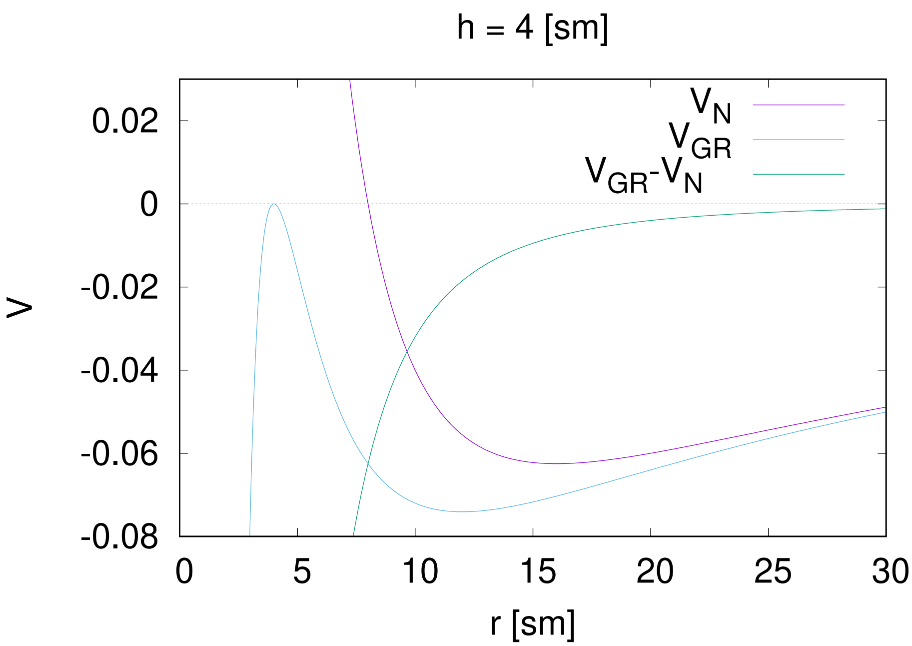


Schwarzschild Singularity.

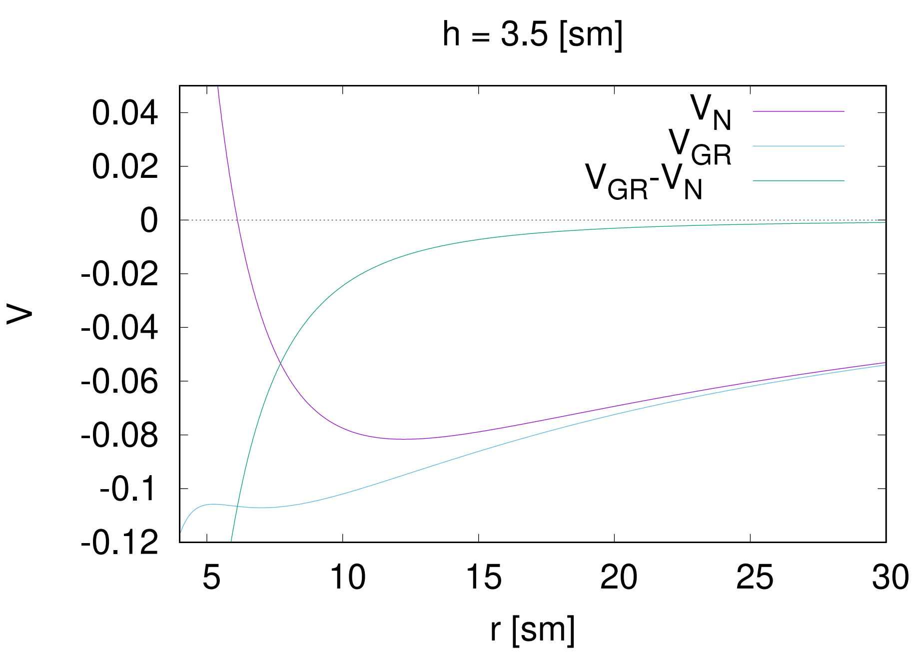


Newton Potential.

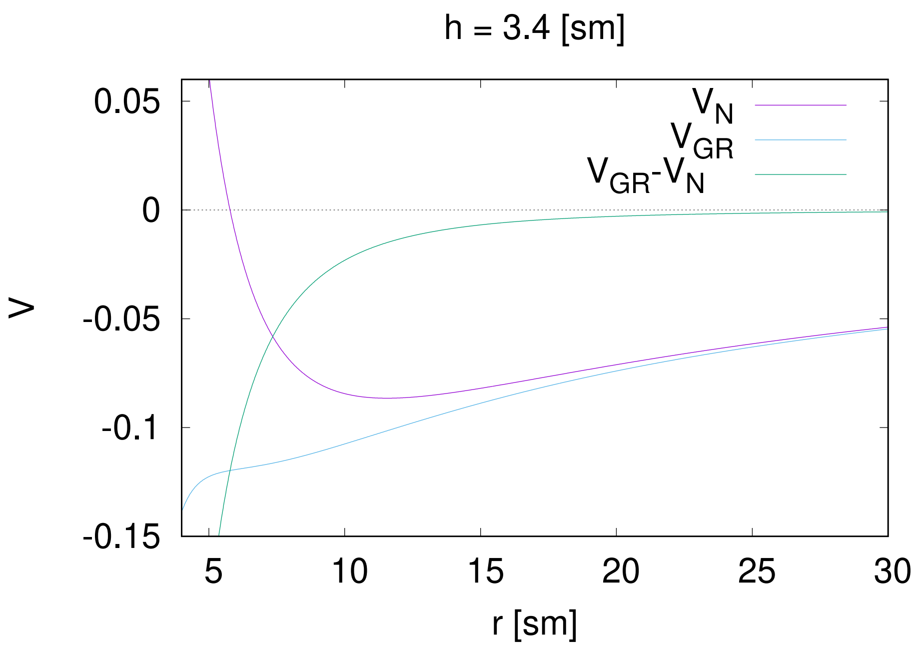
Drecreasing $h \leq 4$



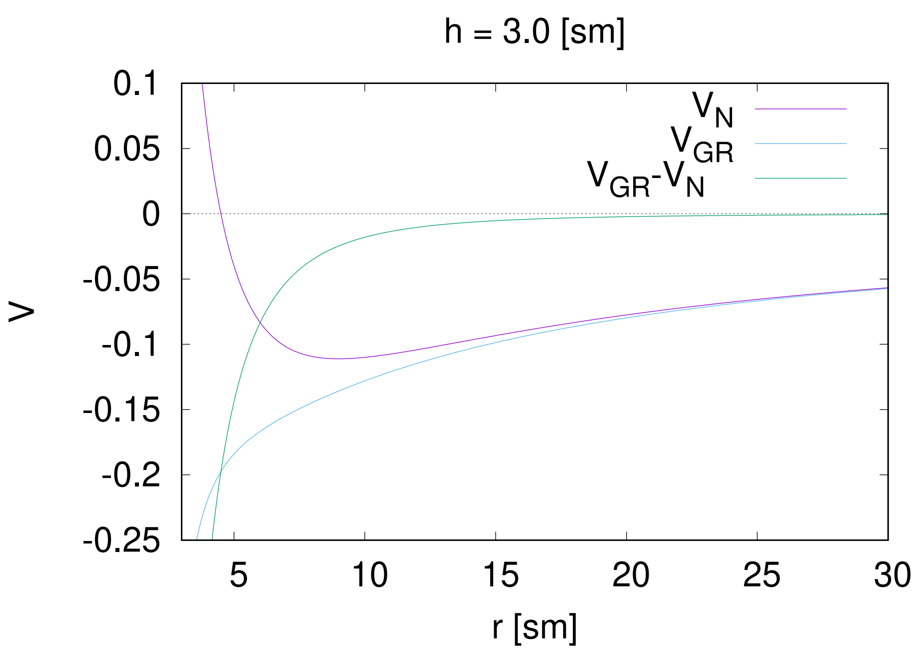
Gravitational Potential.



Gravitational Potential.



Gravitational Potential.



Gravitational Potential.