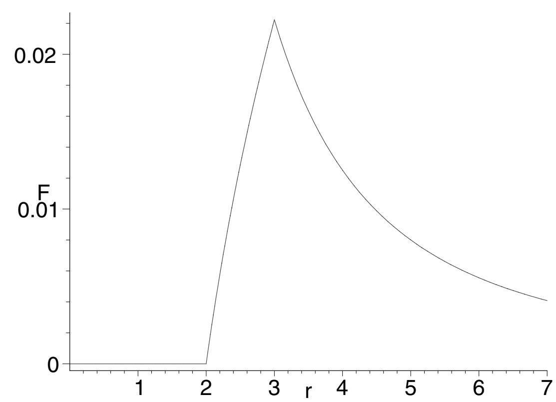
94. (a) When testing for a gravitational force at $r < b$, none is registered. But at points within the shell $b \le r \le a$, the force will increase according to how much mass M' of the shell is at smaller radius. Specifically, for $b \le r \le a$, we find

$$F = \frac{GmM'}{r^2} = \frac{GmM\left(\frac{r^3-b^3}{a^3-b^3}\right)}{r^2} .$$

Once $r = a$ is reached, the force takes the familiar form GmM/r^2 and continues to have this form for $r > a$. We have chosen $m = 1$ kg, $M = 3 \times 10^9$ kg, $b = 2$ m and $a = 3$ m in order to produce the following graph of F versus r (in SI units).



(b) Starting with the large r formula for force, we integrate and obtain the expected $U = -GmM/r$ (for $r \ge a$). Integrating the force formula indicated above for $b \le r \le a$ produces

$$U = \frac{GmM\left(r^3 + 2b^3\right)}{2r\left(a^3 - b^3\right)} + C$$

where C is an integration constant that we determine to be

$$C = -\frac{3GmMa^2}{2a\left(a^3 - b^3\right)}$$

so that this U and the large r formula for U agree at $r = a$. Finally, the $r < a$ formula for U is a constant (since the corresponding force vanishes), and we determine its value by evaluating the previous U at $r = b$. The resulting graph is shown below.