Possibly useful formulae

$$\vec{F} = -\vec{\nabla}U(\vec{r})$$
$$U(x) = -\int_{x_0}^{x} dx' F(x')$$
$$\frac{1}{2}m(v_2^2 - v_1^2) = \int_{x_1}^{x_2} dx' F(x')$$

Rocket with gravity

$$m\dot{v} + u\dot{m} = -mg$$

Cylindrical coordinates

$$\hat{r} = \cos\phi\hat{i} + \sin\phi\hat{j}$$
$$\hat{\phi} = -\sin\phi\hat{i} + \cos\phi\hat{j}$$
$$\vec{v} = \dot{r}\hat{r} + r\dot{\phi}\hat{\phi} + \dot{z}\hat{z}$$
$$\vec{a} = (\ddot{r} - r\dot{\phi}^2)\hat{r} + (2\dot{r}\dot{\phi} + r\ddot{\phi})\hat{\phi} + \ddot{z}\hat{z}$$

Spherical coordinates

$$\hat{r} = \sin\theta\cos\phi\hat{i} + \sin\theta\sin\phi\hat{j} + \cos\theta\hat{k}$$
$$\hat{\theta} = \cos\theta\cos\phi\hat{i} + \cos\theta\sin\phi\hat{j} - \sin\theta\hat{k}$$
$$\hat{\phi} = -\sin\phi\hat{i} + \cos\phi\hat{j}$$
$$\vec{v} = \dot{r}\hat{r} + r\dot{\theta}\hat{\theta} + r\dot{\phi}\sin\theta\hat{\phi}$$
$$\vec{a} = \hat{r}(\ddot{r} - r\dot{\theta}^2 - r\dot{\phi}^2\sin\theta) + \hat{\theta}(r\ddot{\theta} + 2\dot{r}\dot{\theta} - r\dot{\phi}^2\sin\theta\cos\theta) + \hat{\phi}(r\ddot{\phi}\sin\theta + 2r\dot{\theta}\dot{\phi}\cos\theta + 2\dot{r}\dot{\phi}\sin\theta)$$
$$\hat{r}\times\hat{\theta} = \hat{\phi};\ \hat{\phi}\times\hat{r} = \hat{\theta};\ \hat{\theta}\times\hat{\phi} = \hat{r}$$

Quadratic formula:

$$\text{if } ax^2 + bx + c = 0,$$
$$\text{then} \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
$$\cos(a+b) = \cos a\cos b - \sin a\sin b$$
$$\sin(a+b) = \sin a\cos b + \cos b\sin a$$

Taylor series:

$$f(x) = f(x_0) + \left(\frac{df}{dx}\right)_{x=x_0}(x - x_0) + \frac{1}{2!}\left(\frac{d^2f}{dx^2}\right)_{x=x_0}(x - x_0)^2 + \mathcal{O}(x - x_0)^3$$

$$\int \frac{dx}{x+a} = \ln(x+a) + C, \quad \int e^x dx = e^x + C,$$
$$\int \ln x dx = x\ln x - x + C, \quad \int \sin x dx = -\cos x + C,$$
$$\int \cos x dx = \sin x + C, \quad \int \frac{dx}{x^2 + a^2} = \frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right)$$
$$\int \frac{xdx}{\sqrt{x^2 + a^2}} = \sqrt{a^2 + x^2}.$$

$$r(\phi) = \frac{\alpha}{1 + \varepsilon\cos\phi} \quad \alpha = \frac{l^2}{GM} \quad \varepsilon = \sqrt{1 + \frac{2el^2}{G^2M^2}}$$

$$\vec{\nabla}\times\vec{v} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ v_x & v_y & v_z \end{vmatrix} \quad \vec{\nabla} = \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}$$

$$\tilde{f}(\omega) = \int_{-\infty}^{\infty} f(t)\exp(-i\omega t)dt,$$
$$f(t) = \int_{-\infty}^{\infty} \tilde{f}(\omega)\exp(i\omega t)\frac{d\omega}{2\pi}$$

$$\omega_d = \omega_n\sqrt{1 - \zeta^2}, \quad \zeta = \frac{c}{2m\omega_n}$$
$$G(t) = \frac{\sin(\omega_d t)}{m\omega_d}\exp\left(-\frac{ct}{2m}\right),$$
$$|\tilde{G}(\omega)| = \frac{1}{k}\frac{1}{\sqrt{\left(1 - \left(\frac{\omega}{\omega_n}\right)^2\right)^2 + 4\left(\frac{\omega}{\omega_n}\right)^2\zeta^2}}$$
$$\phi(\omega) = \tan^{-1}\left[2\zeta\omega\omega_n/(\omega_n^2 - \omega^2)\right]$$
$$\tilde{x}(\omega) = \tilde{G}(\omega)\tilde{F}(\omega)$$

$$\int_{-\infty}^{\infty} f(t)\delta(t-a)dt = f(a)$$
$$a_n = \frac{2}{T}\int_T F(t)\cos(2n\pi t/T)dt$$
$$b_n = \frac{2}{T}\int_T F(t)\sin(2n\pi t/T)dt$$

$$\vec{F}^{\text{fictitious}} = -m\vec{a}_0 - 2m\vec{\omega}\times\vec{v}^{\text{relative}} - m\vec{\omega}\times[\vec{\omega}\times\vec{r}] - m\dot{\vec{\omega}}\times\vec{r}$$