$$\sum \vec{F} = m\vec{a}$$

$$mg - Kv^2 = ma$$

$$mg - Kv^2 = mv'$$

$$\frac{dv}{dt} = g - \frac{k}{m}v^2 \qquad \int \frac{dv}{\frac{mg}{k} - v^2} = \frac{k}{m}\int dt$$

$$\int \frac{dv}{g - \frac{k}{m}v^2} = \int dt \qquad \int \frac{dv}{\left(\sqrt{\frac{mg}{k}} - v\right)\left(\sqrt{\frac{mg}{k}} + v\right)} = \frac{k}{m}\int dt$$

$$\int \frac{dv}{\frac{k}{m}\left(\frac{mg}{k} - v^2\right)} = \int dt$$

$$\frac{1}{\left(\sqrt{\frac{mg}{k}}+v\right)\left(\sqrt{\frac{mg}{k}}-v\right)} = \frac{A}{\sqrt{\frac{mg}{k}}+v} + \frac{B}{\sqrt{\frac{mg}{k}}-v}$$

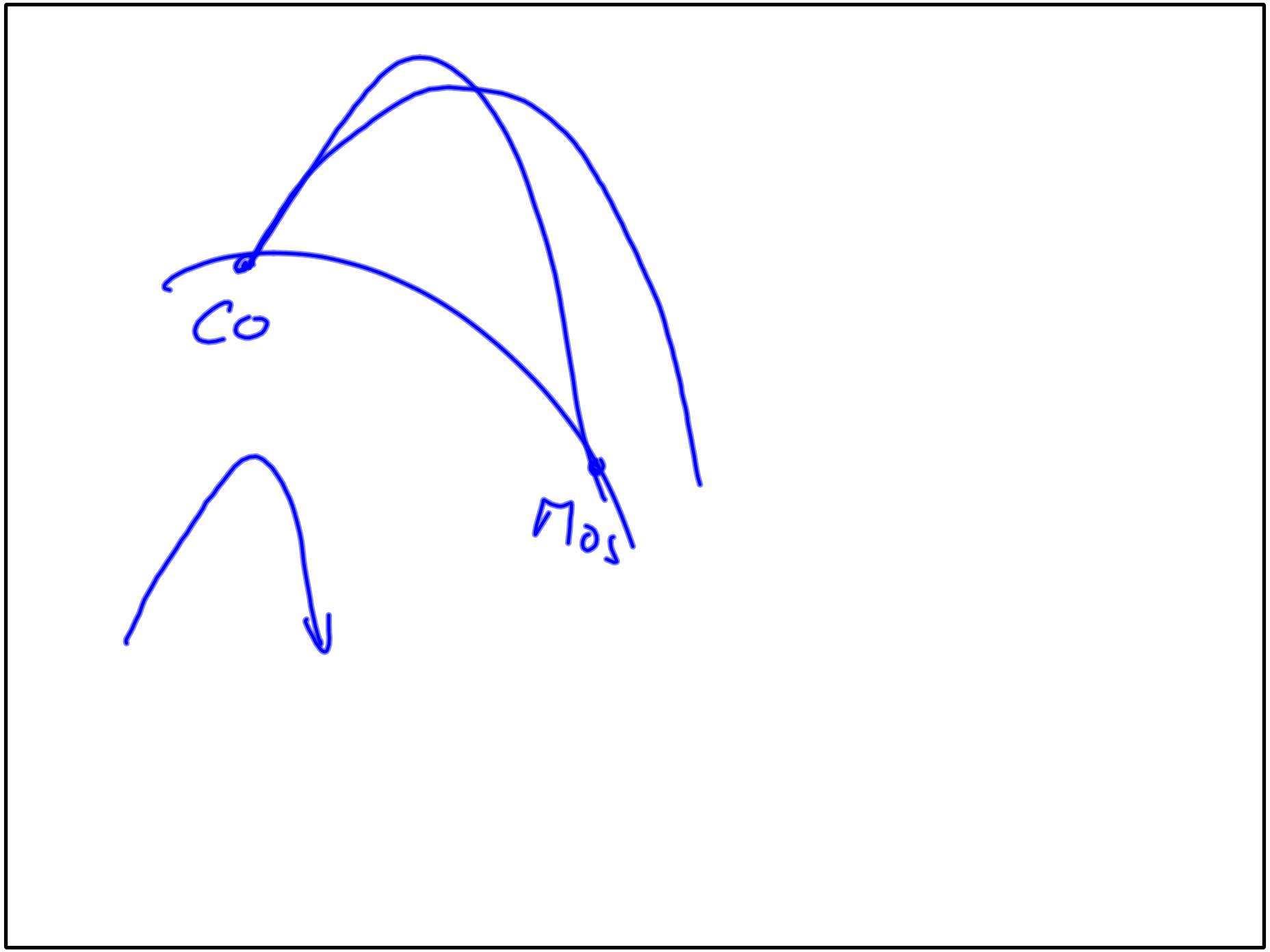
$$0v + 1 = A\sqrt{\frac{mg}{k}} - Av + B\sqrt{\frac{mg}{k}} + Bv$$

$$0 = -A + B$$

$$1 = A\sqrt{\frac{mg}{k}} + B\sqrt{\frac{mg}{k}}$$

$$1 = B\sqrt{\frac{mg}{k}} + B\sqrt{\frac{mg}{k}} \qquad 1 = 2B\sqrt{\frac{mg}{k}}$$

$$B = \frac{1}{2}\sqrt{\frac{k}{mg}}$$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$$\frac{1}{2}\sqrt{\frac{k}{mg}}\left(\int \frac{dv}{\sqrt{\frac{mg}{k}}+v} + \int \frac{dv}{\sqrt{\frac{mg}{k}}-v}\right) = \frac{k}{m}\int dt$$

$$\frac{1}{2}\sqrt{\frac{k}{mg}}\left(\ln\left|\sqrt{\frac{mg}{k}}+v\right| - \ln\left|\sqrt{\frac{mg}{k}}-v\right|\right) = \frac{kt}{m} + C$$

$$\frac{1}{2}\sqrt{\frac{k}{mg}}\ln\left|\frac{\sqrt{\frac{mg}{k}}+v}{\sqrt{\frac{mg}{k}}-v}\right| = \frac{Kt}{m} + C$$

$$\ln\left|\frac{\sqrt{\frac{mg}{k}}+v}{\sqrt{\frac{mg}{k}}-v}\right| = \frac{2k}{m}\sqrt{\frac{mg}{k}}\,t + D$$

$$e^{\ln\left|\frac{\sqrt{\frac{mg}{k}}+v}{\sqrt{\frac{mg}{k}}-v}\right|} = e^{\frac{2k}{m}\sqrt{\frac{mg}{k}}\,t + D}$$

$v(0)=0$, $y'(0)=v$

$$\frac{\sqrt{\frac{mg}{k}}+v}{\sqrt{\frac{mg}{k}}-v} = E\,e^{\frac{2k}{m}\sqrt{\frac{mg}{k}}\,t}$$

$$\frac{\sqrt{\frac{mg}{k}}+v}{\sqrt{\frac{mg}{k}}-v} = e^{\frac{2k}{m}\sqrt{\frac{mg}{k}}\,t}$$