

As part of an examination a few years ago, a student went through the algebraic manipulations on an exam shown in the figure at the right below. Without knowing what the symbols mean, but given the information at the left about the dimensions associated with each symbol, can you decide

If the final equation is correct?

If the final equation is not correct, if the starting equation necessarily wrong?

If the final equation is not correct and the starting equation is not wrong, can you find the error using dimensional analysis?

$$\begin{aligned}[M] &= M \\ [g] &= L/T^2 \\ [h] &= L \\ [\omega] &= 1/T \\ [v] &= L/T \\ [R] &= L \\ [I] &= ML^2\end{aligned}$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}(MR^2)\omega^2$$

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}(MR^2)\left(\frac{v^2}{R}\right)^2$$

$$gh = \frac{1}{2}v^2 + \frac{1}{2}v^4$$