A ball is dropped from rest at $O$. It passes a window which has a height $h$, in a time interval $t_{AB}$. Let down be positive.

Let $||\vec{v}|| \equiv v$ be the speed of the ball. Identify the correct pair of equations for the speeds $v_A$ and $v_B$ that one may use to solve for $v_B$, where $v_A$ and $v_B$ are speeds and $\Delta t = t_{AB} = t_B - t_A$.

A) $v_A - v_B = g\ t_{AB}$ and $v_A + v_B = \frac{h}{t_{AB}}$

B) $v_A - v_B = g\ t_{AB}$ and $\frac{v_A + v_B}{2} = \frac{h}{t_{AB}}$

C) $v_B - v_A = g\ t_{AB}$ and $v_A + v_B = \frac{h}{t_{AB}}$

D) $v_B - v_A = g\ t_{AB}$ and $\frac{v_A + v_B}{2} = \frac{h}{t_{AB}}$
The definition of acceleration implies that \( v_B - v_A = g t_{AB} \). For a constant acceleration, the average speed between \( A \) and \( B \) is given by

\[
\frac{v_{avg}}{2} = \frac{h}{t_{AB}}.
\]

Multiply the first by one-half and add to the second

\[
\frac{1}{2} v_B - \frac{1}{2} v_A = \frac{1}{2} g t_{AB}
\]

\[
\frac{1}{2} v_B + \frac{1}{2} v_A = \frac{h}{t_{AB}} \quad \text{adding, we have}
\]

\[
v_B = \frac{h}{t_{AB}} + \frac{1}{2} g t_{AB}.
\]

Answer D.

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