

$$g = 9.81 \text{ m/s}^2$$

$$a = -g = -9.81 \text{ m/s}^2$$

$$\boxed{a = \text{const}}$$



$$x(t) = x_0 + v_0(t - t_0) + \frac{1}{2}a(t - t_0)^2$$

$$v(t) = v_0 + a(t - t_0)$$

$$v^2(x) = v_0^2 + 2a(x - x_0)$$

$$t_0 = 0 \quad a = -g$$

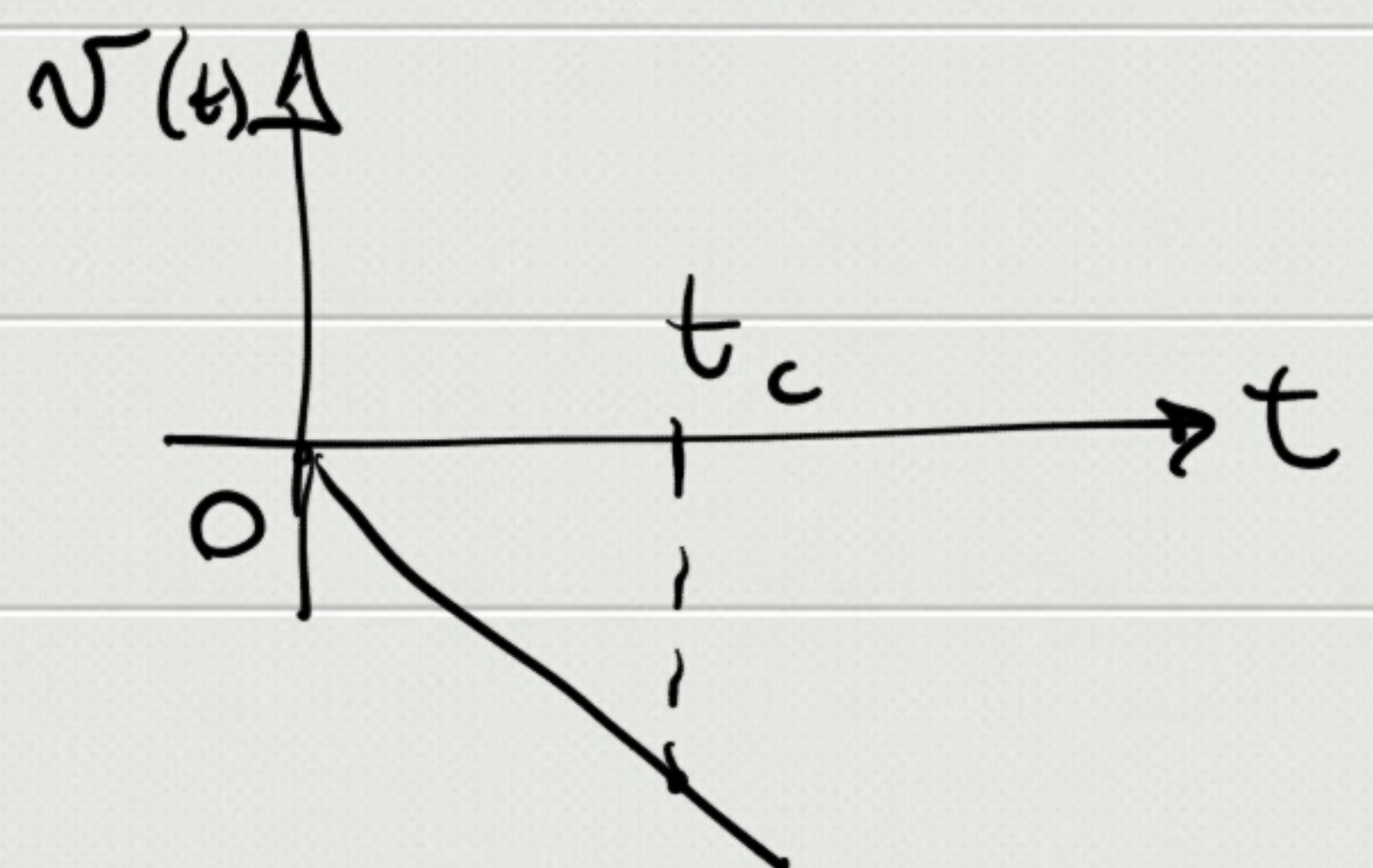
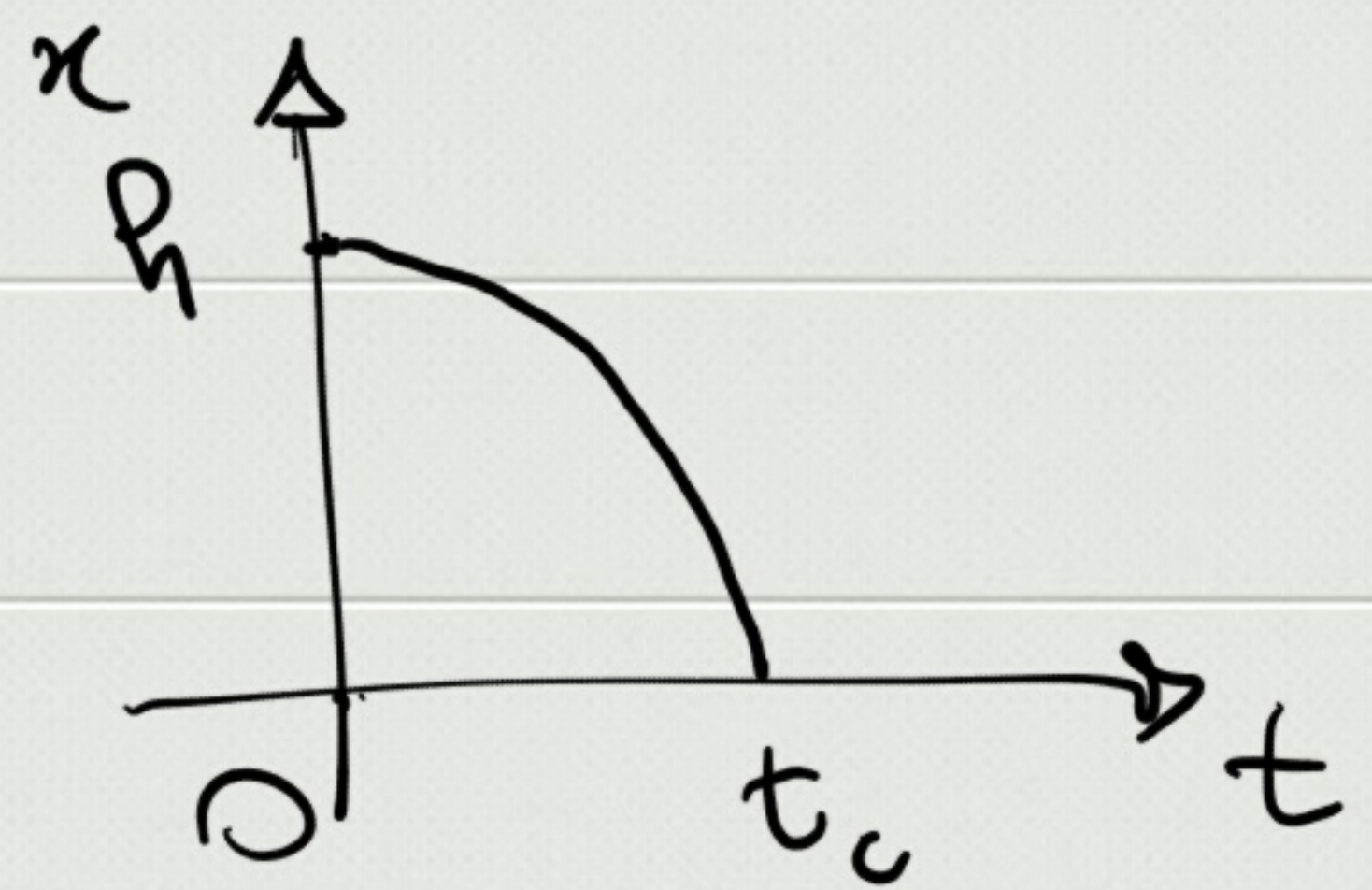
$$\boxed{x(t) = x_0 + v_0 t - \frac{1}{2}gt^2}$$

$$\boxed{v(t) = v_0 - gt}$$

$$\boxed{v^2(x) = v_0^2 - 2g(x - x_0)}$$

$$x_0 = h > 0 \quad v_0 = 0$$

$$\begin{aligned} x(t) &= h - \frac{1}{2} g t^2 \\ v(t) &= -g t \\ v^2(x) &= -2g(x-h) \end{aligned}$$



$$t(x) = \sqrt{\frac{2(h-x)}{g}}$$

$$t_c = t(x=0) = \sqrt{\frac{2h}{g}}$$

$$v_c = v(t_c) = -g \sqrt{\frac{2h}{g}} = -\sqrt{2gh}$$

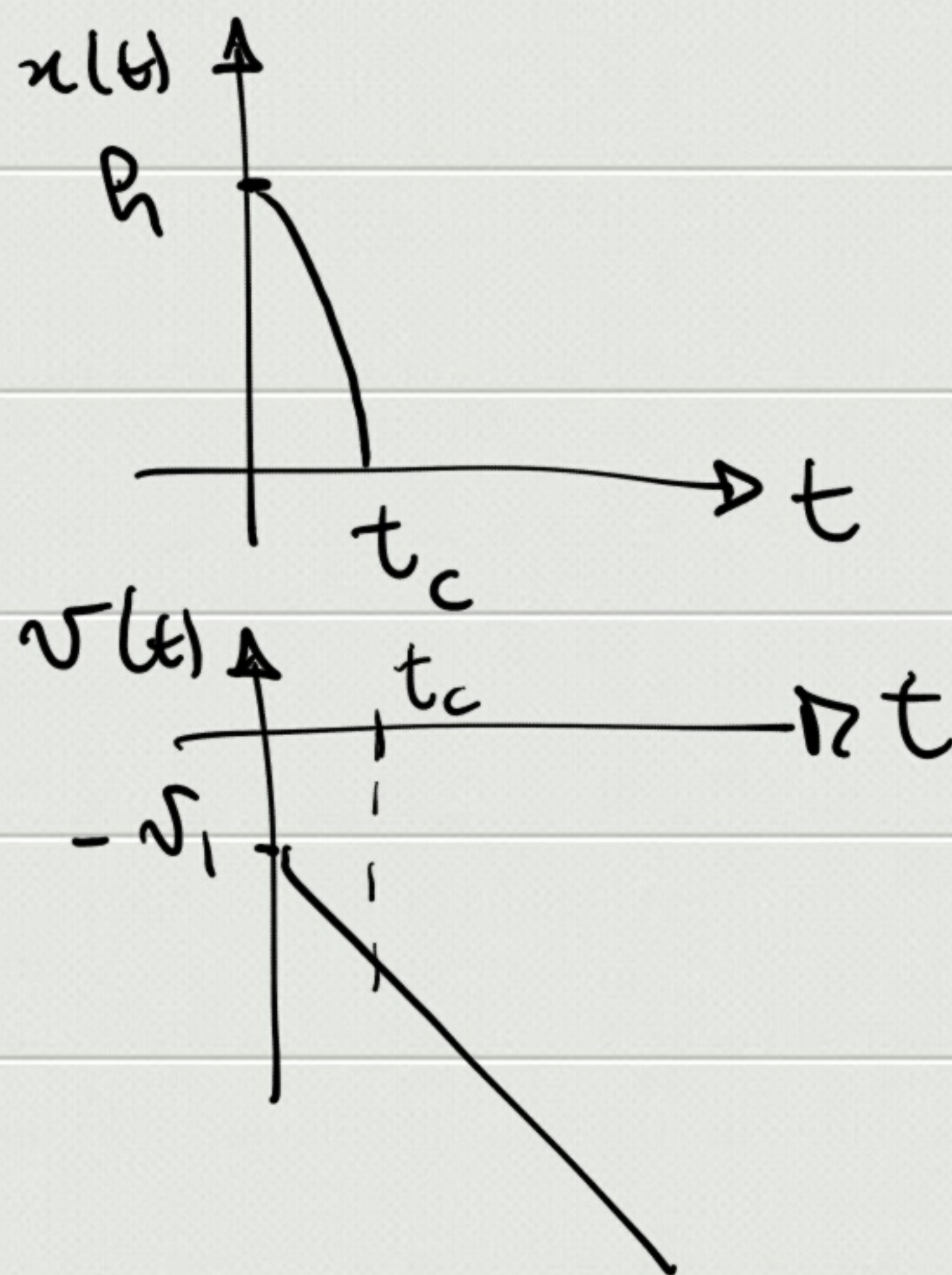
$$v(x) = -\sqrt{2g(h-x)} \Rightarrow v_c = v(x=0) = -\sqrt{2gh}$$

$$x_0 = h \quad v_0 = -v_1 < 0 \quad (v_1 > 0)$$

$$x(t) = h - v_1 t - \frac{1}{2} g t^2$$

$$v(t) = -v_1 - g t$$

$$v^2(x) = v_1^2 - 2g(x-h)$$



$$g t^2 + 2 v_1 t + 2(x-h) = 0$$

$$t = \frac{-v_1 \pm \sqrt{v_1^2 - 2g(x-h)}}{g}$$

$$t_c = t(x=0) = \frac{-v_1 \pm \sqrt{v_1^2 + 2gh}}{g}$$

$$v_c = v(t_c) = -v_1 - g t_c$$

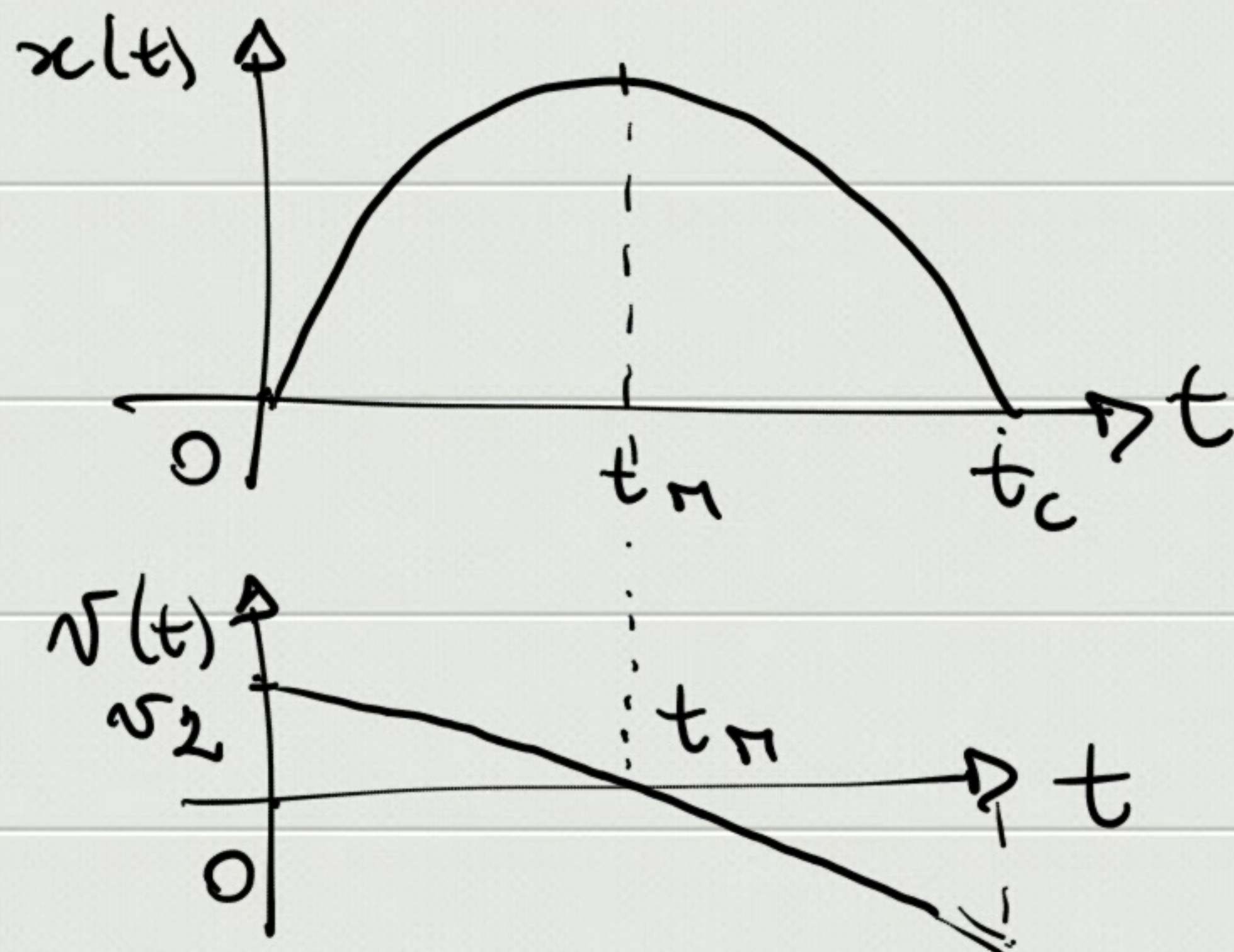
$$v_c = v(x=0) = -\sqrt{v_1^2 + 2gh}$$

$$x_0 = 0 \quad v_0 = v_2 > 0$$

$$x(t) = v_2 t - \frac{1}{2} g t^2$$

$$v(t) = v_2 - g t$$

$$v^2(x) = v_2^2 - 2 g x$$



$$t_n: v(t_n) = 0 \Rightarrow v_2 - g t_n = 0 \Rightarrow \boxed{t_n = \frac{v_2}{g}}$$

$$t_c = 2 t_n$$

$$g t^2 - 2 v_2 t - 2 x = 0$$

$$\Rightarrow t = \frac{v_2 \pm \sqrt{v_2^2 + 2 g x}}{g}$$

$$v_c = v(2 t_n) = v\left(\frac{2 v_2}{g}\right) = v_2 - g \frac{2 v_2}{g} = -v_2$$