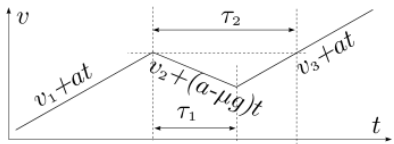
Problem 10. Ice-rally ***(7 points)***

i. (2 pts) Since at the very beginning, the effect of the air friction is negligible, the acceleration (i.e. the tangent of the graph) gives us the ratio of the friction force F_f and the mass m, i.e. μg. From the graph, this tangent is $\mu g = 1.0\,\mathrm{m/s^2}$, hence $\mu = 0.1$.



ii. (2.5 pts) When the driving force stops, the acceleration is reduced by $F_f/m = \mu g$, i.e. from the slope at the current point of the graph we need to subtract the slope of it at the origin. A close-up sketch of the graph around the period of gear change is given in Fig. After the gear change, the new graph follows the ideal graph, but is shifted rightwards by τ_2, this shift is marked also in Fig. Since $2\tau_1 = \tau_2$, the ascending and descending slopes in that close-up sketch must be of equal steepness, i.e. $a = \mu g/2$. So, the gear change takes place at that speed, when the acceleration is twice smaller than at zero-speed. From the graph we can find that $v_0 \approx 25\,\mathrm{m/s}$.

iii. (2.5 pts) The distance difference is the surface area S between the actual $v(t)$ graph, and the ideal one. These graphs coincide for $v < v_0$ and upon achieving the value $v = v_t$. So, the area S is enclosed into the range $v_t > v > v_0$, where the actual graph is, in fact, just the ideal graph, but shifted rightwards by τ_2. This area has a shape of a narrow curved stripe, the horizontal width of which is at every value of v equal to τ_2. One can divide this stripe into tiny horizontal layers of height δ and width τ_2. If we sum up the surface areas of these layers, we can bring τ_2 before the braces; then, the sum of the layer widths goes into the braces and yields $v_t - v_0$. So, the surface area $S = \tau_2(v_t - v_0) \approx 15\,\mathrm{m}$.