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GPS and Relativity

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The GPS doesn't need relativistic corrections because the satellites are constantly synchronized by earth stations. But relativistic corrections exist and have different values than usually claimed.

Orbital speed shift:

$$v_O = \sqrt{\frac{GM}{R_O}} = 3.9\times10^3\, ms^{-1}$$

$$M = 6\times10^{24}\, kg\,; \quad R_O = 2.66\times10^7\, m$$

$$t = \frac{t_0}{\sqrt{1-v^2/c^2}} \quad \Leftrightarrow \quad \Delta t = t_0 \frac{v}{c^2}\Delta v \;\; ; \quad \Delta v \approx v$$

Time shift per day:

$$\Delta t = 24\times3600\frac{v^2}{c^2} = 14.6\mu s$$

Gravitational shift:

$$v_1 = \sqrt{\frac{2GM}{R_T}} = 1.12\times10^4 \;\; ; \quad R_T = 6.4\times10^6\, m$$

$$v_2 = \sqrt{\frac{2GM}{R_O}} = 5.84\times10^3$$

$$\Delta v = v_1 - v_2 = 5.7\times10^3 \;\; ; \quad v \approx \Delta v$$

$$\Delta t = 24\times3600\frac{v^2}{c^2} = 31.4\mu s$$

Total shift per day:

$$\Delta T = 31.4 - 14.6 = 16.8\mu s$$