72. The speed of the submarine going eastward is

$$v_{\text{east}} = v_{\text{equator}} + v_{\text{sub}}$$

where $v_{\text{sub}} = 16000/3600 = 4.44$ m/s. The term v_{equator} is the speed that any point at the equator (at radius $R = 6.37 \times 10^6$ m) would have in order to keep up with the spinning earth. With $T = 1\,\text{day} = 86400\,\text{s}$, we note that $v_{\text{equator}} = R\omega = R2\pi/T = 463$ m/s and is much larger than v_{sub}. Similarly, when it travels westward, its speed is

$$v_{\text{west}} = v_{\text{equator}} - v_{\text{sub}} \ .$$

The effective gravity g_e (or apparent gravity) combines the gravitational pull of the earth g (which cancels when we take the difference) and the effect of the centripetal acceleration v^2/R. Considering the two motions of the submarine, the difference is therefore

$$\begin{aligned} \Delta g_e = g_e' - g_e &= \frac{v_{\text{east}}^2}{R} - \frac{v_{\text{west}}^2}{R} \\ &= \frac{1}{R}\left((v_{\text{equator}} + v_{\text{sub}})^2 - (v_{\text{equator}} - v_{\text{sub}})^2\right) \\ &= \frac{4v_{\text{equator}}v_{\text{sub}}}{R} \quad = \quad \frac{8\pi v_{\text{sub}}}{T} \end{aligned}$$

where in the last step we have used $v_{\text{equator}} = R2\pi/T$. Consequently, we find

$$\frac{\Delta g_e}{g} = \frac{8\pi v_{\text{sub}}}{gT} = \frac{8\pi(4.44)}{(9.8)(86400)} = 1.3 \times 10^{-4} \ .$$

The problem asks for $\Delta g/g$ for *either* travel direction, and since our computation examines eastward travel as opposed to westward travel, then we infer that either-way travel versus no-travel should be half of our result. Thus, the answer to the problem is $\frac{1}{2}(1.3 \times 10^{-4}) = 6.6 \times 10^{-5}$.