2. Speed camera (6 points) — *Mihkel Kree.*

In this problem, we analyse the working principle of a speed camera. The transmitter of the speed camera emits an electomagnetic wave of frequency $f_0 = 24\,\mathrm{GHz}$ having waveform $\cos(2\pi f_0 t)$. The wave gets reflected from an approaching car moving with speed v. The reflected wave is recorded by the receiver of the speed camera.

i) *(2 points)* Express the freqency f_1 of the reflected wave.

ii) *(2 points)* In the speed camera, the received waveform is multiplied with the original emitted waveform. Express all the frequency components present in the multiplied signal.

iii) *(2 points)* Given the lowest frequency component $f_{\mathrm{low}} = 4.8\,\mathrm{kHz}$ present in the multiplied signal, calculate the speed of the car v. *Note:* the speed of light $c = 3.0 \times 10^8\,\mathrm{m/s}$ and the following trigonometric identity might turn to be useful:

$$\cos\alpha\cos\beta = \frac{1}{2}\left[\cos(\alpha+\beta) + \cos(\alpha-\beta)\right].$$