2. Speed camera

i) The Doppler shift formula has to be applied twice. First, the observer on the approaching car sees both the incoming and reflected wave with frequency $f' = f_0(1 + v/c)$. Now, the observer at the speed camera sees the reflected wave Doppler shifted to $f_1 = f'' = f'(1 + v/c) = f_0(1 + v/c)^2$. Finally, we can simplify:

$$f_1 = f_0(1 + v/c)^2 \approx f_0(1 + 2v/c).$$

ii) Using the trigonometric identity given in the problem, we can express the product of two waves simply as a sum of waves

$$\cos(2\pi f_1 t)\cos(2\pi f_0 t) = \frac{1}{2}\cos[2\pi(f_1 + f_0)t] + \frac{1}{2}\cos[2\pi(f_1 - f_0)t],$$

where we can easily identify two frequency components $f_{\text{high}} = f_1 + f_0$ and $f_{\text{low}} = f_1 - f_0$.

iii) We can express $f_{\text{low}} = f_1 - f_0 = 2f_0 v/c$ and calculate the speed of car as

$$v = \frac{f_{\text{low}}}{2f_0}\, c = 30\,\text{m/s}.$$