e) To find the group velocity as the waves travel together through the oil, we start with the sum of the waves:

$$\text{Sum} = A\sin(k_1'x - \omega_1 t) + A\sin(k_2'x - \omega_2 t)$$

Use trig ID $\sin(P) + \sin(Q) = 2\sin\left(\frac{P+Q}{2}\right)\cos\left(\frac{P-Q}{2}\right)$

So

$$\text{Sum} = 2A\sin\left(\frac{(k_1'+k_2')x}{2} - \frac{(\omega_1+\omega_2)t}{2}\right)\cos\left(\frac{k_1'-k_2'}{2}x - \frac{\omega_1-\omega_2}{2}t\right)$$

↑ use for V_{ph} ↑ use for V_{gr}

$$V_{gr} = \frac{\omega_1-\omega_2}{k_1'-k_2'} = 2.66\times10^8\ \frac{m}{s}$$

f) The phase velocity is

$$V_{ph} = \frac{\omega_1+\omega_2}{k_1'+k_2'} = 2.81\times10^8\ \frac{m}{s}$$

So $V_{gr} > V_{ph}$ in this instance, and as usual.