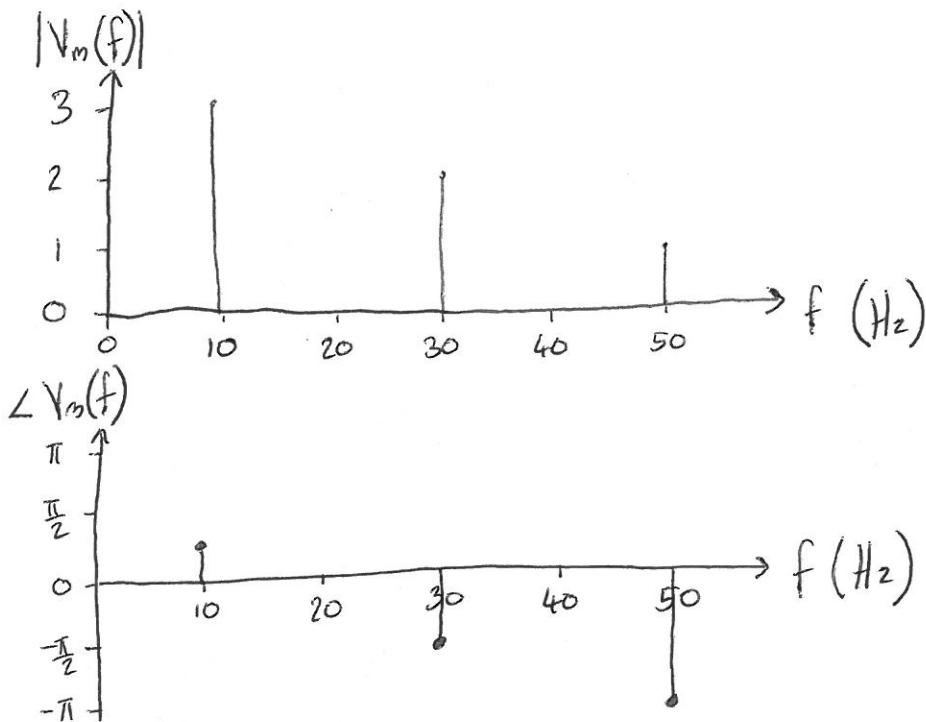
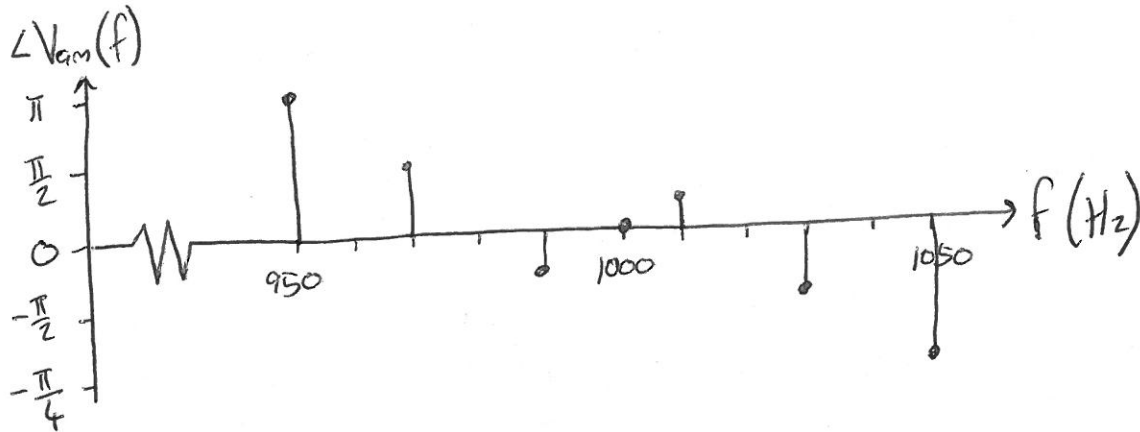
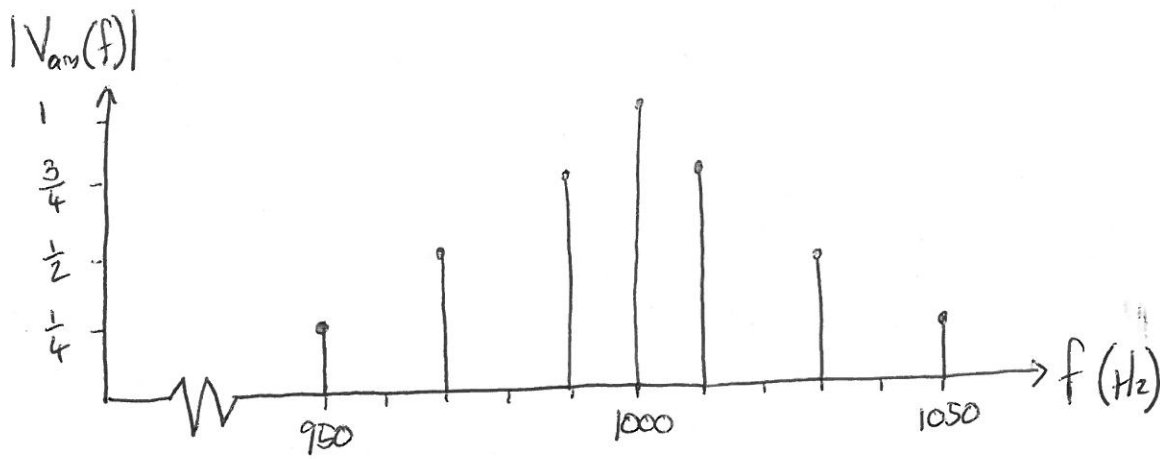


## Lecture 4 exercises

$$1. \quad V_m(t) = 3\cos(20\pi t + \frac{\pi}{4}) + 2\sin(60\pi t) - \cos(100\pi t) \\ = 3\cos(20\pi t + \frac{\pi}{4}) + 2\cos(60\pi t - \frac{\pi}{2}) + \cos(100\pi t - \pi)$$



$$2. \quad v_{am}(t) = \left( \underset{\substack{\uparrow \\ 1}}{V_c} + \underset{\substack{\uparrow \\ 0.5}}{k_m V_m(t)} \right) \cdot \cos \left( \underset{\substack{\uparrow \\ 1000 \text{ Hz}}}{2\pi f_c t} \right) \\ = \left( 1 + \frac{3}{2}\cos(20\pi t + \frac{\pi}{4}) + \cos(60\pi t - \frac{\pi}{2}) + \frac{1}{2}\cos(100\pi t - \pi) \right) \cdot \cos(2\pi f_c t) \\ = \frac{1}{4}\cos(1900\pi t + \pi) + \frac{1}{2}\cos(1940\pi t + \frac{\pi}{2}) + \frac{3}{4}\cos(1980\pi t - \frac{\pi}{4}) \\ \quad + \cos(2\pi f_c t) \\ + \frac{3}{4}\cos(2020\pi t + \frac{\pi}{4}) + \frac{1}{2}\cos(2060\pi t - \frac{\pi}{2}) + \frac{1}{4}\cos(2100\pi t - \pi)$$



3.  $P = \frac{V^2}{2}$  for a sinusoid

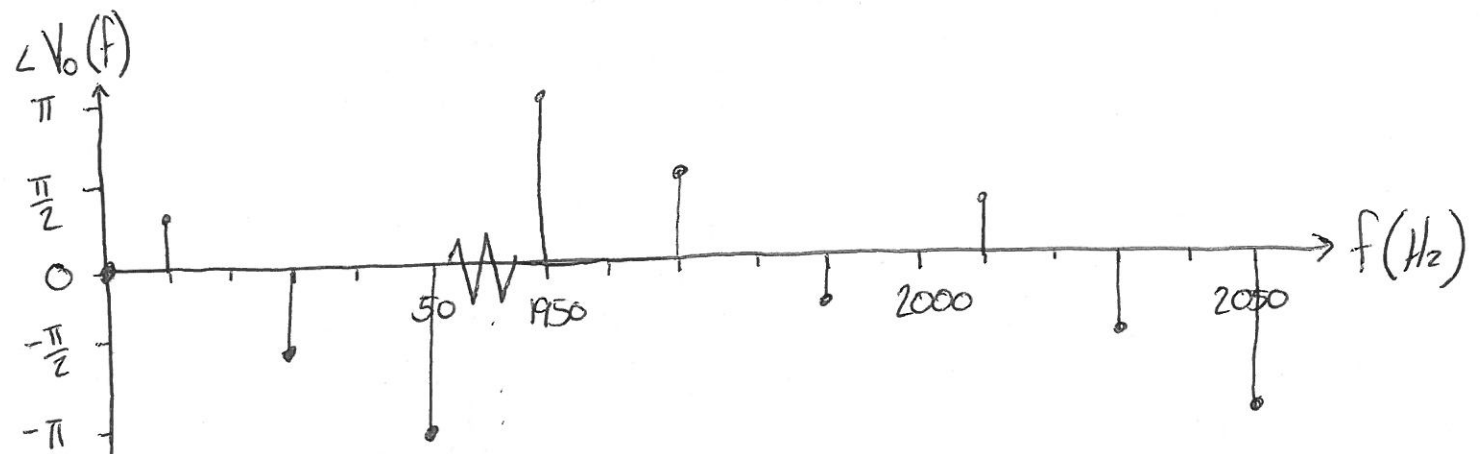
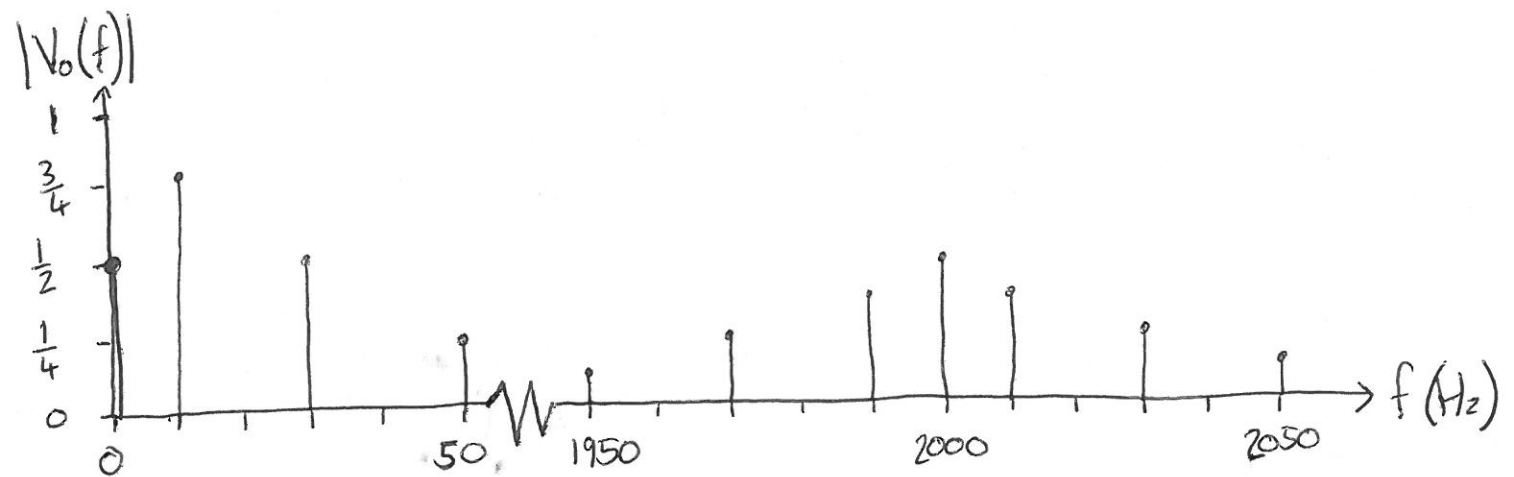
$f$	$\frac{P}{f}$		
950 Hz	$\frac{1}{32}$	} LSB	$\frac{14}{32}$
970 Hz	$\frac{1}{8}$		
990 Hz	$\frac{9}{32}$		
1000 Hz	$\frac{1}{2}$	← carrier	$\frac{16}{32}$
1010 Hz	$\frac{9}{32}$	} USB	$\frac{14}{32}$
1030 Hz	$\frac{1}{8}$		
1050 Hz	$\frac{1}{32}$		

$$\text{fraction of power in sidebands} = \frac{\frac{14}{32} + \frac{14}{32}}{\frac{16}{32} + \frac{14}{32} + \frac{14}{32}} = \frac{7}{11} = 63.6\%$$

4. Coherent demodulation is required because fraction of power in sidebands is greater than  $\frac{1}{3}$ .

$$V_o(t) = V_{am}(t) \cdot \cos(2\pi f_c t)$$

$$= \frac{1}{2} + \frac{3}{4} \cos(20\pi t + \frac{\pi}{4}) + \frac{1}{2} \cos(60\pi t - \frac{\pi}{2}) + \frac{1}{4} \cos(100\pi t - \pi) \\ + \frac{1}{8} \cos(3900\pi t + \pi) + \frac{1}{4} \cos(3940\pi t + \frac{\pi}{2}) + \frac{3}{8} \cos(3980\pi t - \frac{\pi}{4}) \\ + \frac{1}{2} \cos(4000\pi t) \\ + \frac{3}{8} \cos(4020\pi t + \frac{\pi}{4}) + \frac{1}{4} \cos(4060\pi t - \frac{\pi}{2}) + \frac{1}{8} \cos(4100\pi t - \pi)$$



5. See above