Q$_1$:

$$f(t) = \frac{3\sin(30\pi(t-1/20))}{\pi(t-1/20)} \cos 300\pi t$$

- We can break down f(t) into a compound of different functions. From observation,

$$g(t) = \frac{3\sin(30\pi t)}{\pi t}$$

$$h(t) = g(t - 1/20)$$

$$k(t) = h(t)\cos 300\pi t = f(t)$$

- Now, we can utilize known properties of fourier transform to get the transform of f(t).

$$g(t) = \frac{3}{\pi}\left(\frac{30}{30}\right)\frac{\sin(30\pi t)}{t}$$

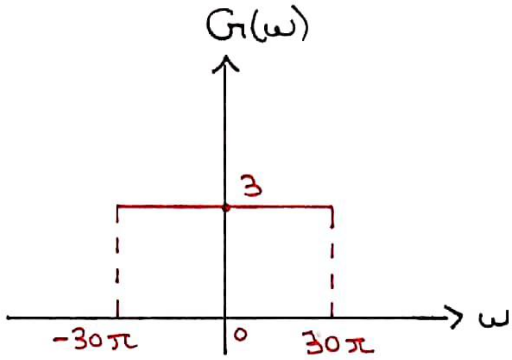
$$= 90\,\frac{\sin(30\pi t)}{30\pi t}$$

$$= 90\,\mathrm{sinc}(30\pi t)$$

→ We know that: $A\,\mathrm{sinc}(at) \longleftrightarrow \frac{A\pi}{a}\,\mathrm{rect}\left(\frac{\omega}{2a}\right)$

$$G(j\omega) = 3\,\mathrm{rect}\left(\frac{\omega}{60\pi}\right)$$

- The magnitude spectrum of which is:



- Using time shift property, we can find the transform of h(t).

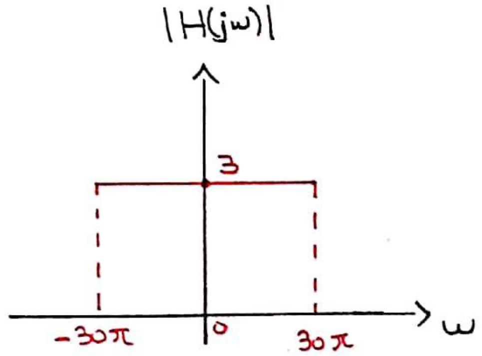
$$h(t) = g(t - 1/20)$$

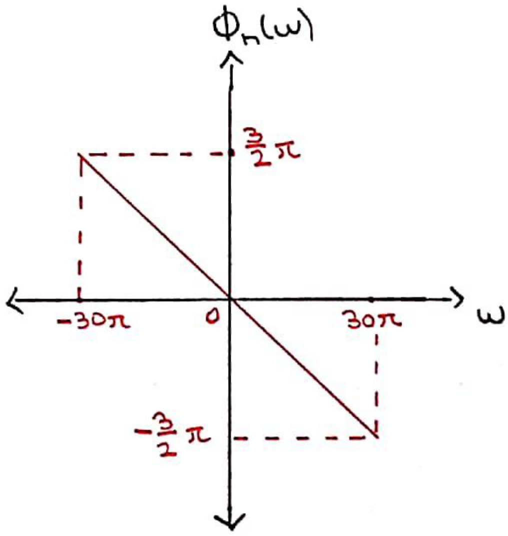
$$H(jw) = \left(e^{-jw/20}\right) 3 \; \text{rect}\left(\frac{w}{60\pi}\right)$$

- $|H(jw)| = |G(jw)|$ and hence, magnitude spectrum is the same.

- $$\phi_h(w) = -\frac{w}{20}$$

- Spectrum of H(jw) are as follows:





- Lastly for $f(t)$, we multiply $h(t)$ with $\cos(300\pi t)$.

$$f(t) = h(t)\cos(300\pi t)$$
$$= h(t)\left[\frac{e^{j300\pi t} + e^{-j300\pi t}}{2}\right]$$

$$F(j\omega) = \frac{1}{2}\left[H(j(\omega-300\pi)) + H(j(\omega+300\pi))\right]$$

$$F(j\omega) = \frac{1}{2}\left[e^{-j\omega/20}\, 3\,\mathrm{rect}\left(\frac{\omega-300\pi}{60\pi}\right) + e^{-j\omega/20}\, 3\,\mathrm{rect}\left(\frac{\omega+300\pi}{60\pi}\right)\right]$$

- Spectrum of $F(j\omega)$