Major Exam I
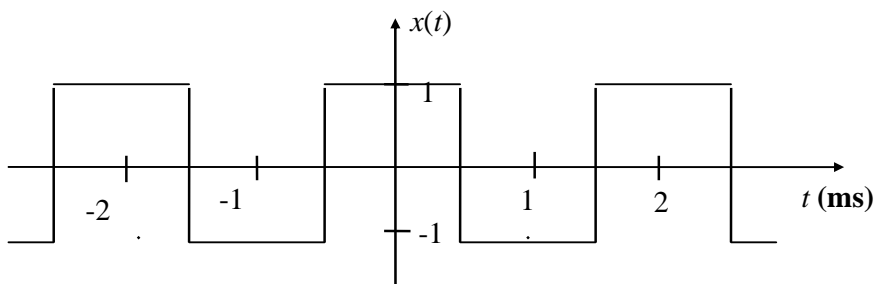
<u>**Sun. Nov. 5 (class-time)**</u>   <u>**Duration: 90 mins**</u>

<u>**Student Name:**</u>   **ID#**

1.   [30 points] For the signal $x(t)$ shown below, find the following:

(a) The trigonometric Fourier series expansion of $x(t)$.

(b) Sketch the Fourier spectrum in the band -3 kHz $\leq f \leq$ 3 kHz. Show all significant points.

(c) If $x(t)$ is used as an input to an ideal LPF with a bandwidth 700 kHz, sketch the spectrum and the waveform of the output of the LPF.

2. [35 points] The signal $m(t)= 3\cos(200\pi t)$ is used to amplitude modulate the carrier $c(t) = 6\cos(1000\pi t)$ resulting in the signal $s(t)$ with a modulation index of 0.9. It is required to recover $m(t)$ from $s(t)$ by coherent detection using a local oscillator whose output is given by $\cos(960\pi t)$. (Note the **frequency mismatch** between the carrier $c(t)$ and the local oscillator). The signal is next fed to a LPF of bandwidth 200 Hz.

    (a) Illustrate the problem by a system block diagram.

    (b) Sketch the spectrum of $s(t)$. Show all significant values.

    (c) Determine the power efficiency of $s(t)$.

(d) Sketch the spectrum at the output of the LPF. Show all significant values.

(e) Express the filter output in the time domain.

(f) Comment on the effect of frequency mismatch.

3. [35 points] The AM broadcast band extends from 535 kHz to 1605 kHz. Transmission is by AM (with carrier). Each station is allocated a bandwidth of 10 kHz.

   (a) How many stations can the entire band support?

   (b) If the stations are numbered 1, 2, .. starting from the lower side of the band, what is the carrier frequency of the ith station?

   (c) Sketch the block diagram of a superheterodyne receiver.

   (d) Answer the following:
      (i) Which of the two filters has a higher quality factor Q?

      (ii) Which of the two filters is tunable?

(e) Determine the frequency range of the local oscillator such that any station in the band can be received. (the center frequency of the IF filter is 455 kHz).

(f) It is desired to listen to the ith station in the band, what should be the frequency of the local oscillator? Which station is the *image* of the ith station?

(g) Illustrate your answers in **(e)** for $i = 10$.