**TQM3 – Introduction to Maintainability(DSP)**

1. The signal X(t) from an accelerometer, mounted on a pump bearing, contains frequency components up to 500 Hz. The pump shaft rotational speed is 1,179 RPM.

1. (a) Express the pump shaft rotational frequency in Hz.
   * 1. (b) At what rate, must X(t) be sampled in order to reconstruct it without error? Choose one answer from below and explain your choice.

**A.** Less than 500 Hz. **B.** Greater than 500 Hz. **C.** Greater than 1,000 Hz.

2. (a) An acoustic signal picked up from a microphone is sampled at 10 kHz. Calculate the maximum information frequency of the digitized signal.

(b) It was later determined that this signal contained an unexpected frequency component at

6 kHz. Calculate the frequency at which aliasing effect is seen in the digitized signal.

(c)State two approaches you may use to avoid the aliasing problem in this case.

3. State four important causes of vibration in rotating machinery.

1. 4. The rotational speed of an electric motor is 3540 RPM. Calculate the frequency of rotation in Hz. Give an example for each of the following:
2. (a) a harmonic frequency of the rotating speed,
3. (b) a sub-synchronous frequency of the rotating speed,
4. (c) a non-synchronous frequency of the rotating speed.
5. 5. Which of the following characteristics may be detected using time waveform analysis of vibration measurements? Explain.

(a) Impacting in the machine components. (b) Signal Modulation. (c) Strong periodic components.

1. 6. (a) The rotational speed of a pump shaft is 1740 RPM. At what frequencies (Hz) in the spectral domain do you expect to see harmonics of the rotating speed due to (i) imbalance, (ii) bent shaft, and (iii) parallel misalignment?
2. (b) State the directional placement of the accelerometer to measure each of these anomalies.