2a. What is a reference frame? What are the types of reference frames?

b. What is a projectile? Are the horizontal and vertical components of a projectile motion independent? Explain. Define trajectory of a particle.

c. Define work and power.

2a. What do you mean by simple harmonic motion? Give two examples of simple harmonic motion. Are all periodic motions simple harmonic? What force does a simple harmonic oscillator experience?

b. Solve the equation of a simple harmonic oscillator and obtain the position of a simple harmonic oscillator as a function of time.

c. Show that the total mechanical energy of a simple harmonic oscillator is constant.

d. The position of a simple harmonic oscillator as a function of time is given by

$$x(t) = 6\ sin(3.50t - \varphi)\,.$$

Calculate the amplitude, angular frequency, frequency, and time period.

Calculate the initial phase or epoch if $x(t = 0) = 3$.

Calculate the velocity and acceleration at time $t = 2\ sec$.

Solution: Comparing $x(t) = 6\ sin(3.50t - \varphi)$ with $x(t) = A\ sin(\omega t + \varphi)$ we get

The amplitude $A = 6\ m$

The angular frequency $\omega = 3.5\ rad/s$

The frequency $f = \omega/2\pi = 0.56\ s^{-1}$

The time period $T = 2\pi/\omega = 1.79\ s$

The epoch or initial phase is the phase at time $t = 0$

$$x(t = 0) = 3 = 6\ sin(3.50 \times 0 - \varphi) \Longrightarrow \varphi = -\frac{\pi}{6}\ rad$$

Therefore $x(t) = 6\ sin\left(3.50t + \frac{\pi}{6}\right)$

To get the velocity we differentiate the position $x(t)$ with respect to time

$$v(t) = \frac{d}{dx}x(t) = 6 \times 3.50 \; cos\left(3.50t + \frac{\pi}{6}\right)$$

At time $t = 2$ the velocity is $v(t = 2) = 6 \times 3.50 \; cos\left(3.50 \times 2 + \frac{\pi}{6}\right) = 6.81 \; m/s$

Similarly get the acceleration.