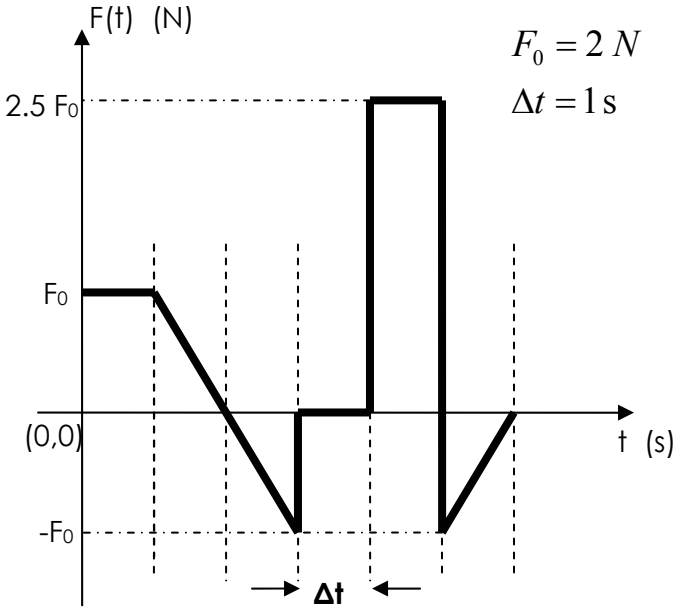
Q.1

a) In a one-dimensional problem, calculate the velocity of a particle of mass m=500g, at $t=6\Delta t$ under the influence of a time-dependent force as given graphically. (Consider that the initial velocity of the particle is zero)

b) Express the time dependence of velocity on time, $v(t)$, in the interval $t=1\text{s}$ to $t=3\text{s}$.



Q.2

The position of a particle as a function of time is given as

$\vec{r}(t) = R[1+\cos(\omega t)]\hat{i} + R\sin(\omega t)\hat{j}$; where R and ω are some constants.

a) Determine the instantaneous velocity vector, $\vec{v}(t)$ (using unit vectors $\hat{i}$ and $\hat{j}$)

b) Determine the instantaneous acceleration vector, $\vec{a}(t)$ (using unit vectors $\hat{i}$ and $\hat{j}$)

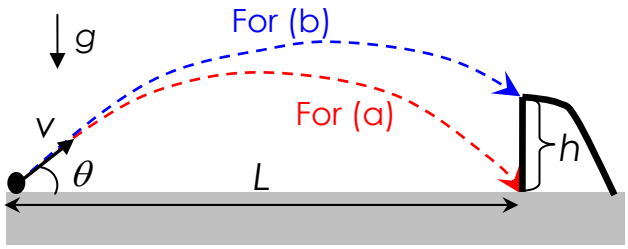
c) What is the mathematical relation between their magnitudes, $|\vec{a}|$ and $|\vec{v}|$?

d) Determine the vector (cross) product of $\vec{v}(t)$ and $\vec{a}(t)$. What is the angle between $\vec{v}(t)$ and $\vec{a}(t)$?

e) Based on the information obtained in previous parts, what is the name for this particular motion?

A useful identity: $\sin^2\theta + \cos^2\theta = 1$

Q.3



Consider a penalty kick illustrated in the figure. Determine the expression for the initial kicking angles θ with respect to the horizontal so that the ball directly hits

a) the bottom of the goal post,

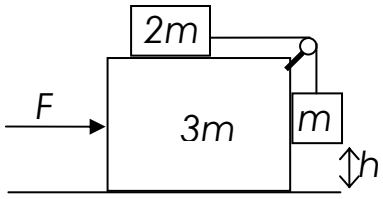
b) the top of the goal post of height *h*.

Give your answers in terms of *v*, *L*, *g* and *h*.

You should simplify your expressions as much as possible.

Useful identities: $2\sin\theta\cos\theta = \sin 2\theta$, $\dfrac{1}{\cos^2\theta} = 1+\tan^2\theta$

Q.4



a) In the system of blocks illustrated in the figure an external horizontal force *F* is applied. What is the magnitude of *F* if the block with mass 2*m* does not move relative to the block under it? (All friction forces and the masses of the pulley and the cord are negligible.)

Draw the free body diagram for each block.

b) If the external force calculated in part (a) is suddenly removed, how long does it take for the block with mass *m* to hit the ground?