For a given $\vec{r}(t) =< f(t), g(t), h(t) >$ where $f(t), g(t), h(t)$ are analytic function respect to time.

1- Show that $\vec{T}(t)$ is orthogonal to $\vec{N}(t)$.

2- These four vectors are not orthogonal to each other.

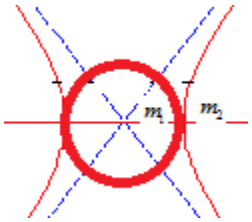
$u_0 =< 1,0,0,0 >\ \ u_1 =< 1,1,0,0 >\ \ u_2 =< 1,1,1,0 >\ \ and\ \ u_4 =< 1,1,1,1 >$

Use Gram-Schmidt orthonormalization to find a set of orthonormal vectors.

Hint: Use $u_0 =< 1,0,0,0 >$ as the first vector and find orthogonal vector to it and so on

3- Explain the reason for dot and cross product for components of acceleration $\vec{a} = a_T \vec{T} + a_N \vec{N}$ Where $a_T = \dfrac{\vec{r}'(t) \bullet \vec{r}''(t)}{|\vec{r}'(t)|}$ and $a_N = \dfrac{|\vec{r}'(t) \times \vec{r}''(t)|}{|\vec{r}'(t)|}$

4- Mass m_1 is moving on a unit Circle (center at origin) with ω_1 and at the same time Mass m_2 is moving on a unit Hyperbola with ω_2. If these masses are connected to each other with a spring, find spring constant at time $t = 0$ sec to show that the potential energy of spring is equal to kinetic energy of the whole system.



5- Given $a =< 0, -g > m/s^2$ and $v(0) =< vCos\theta, vSin\theta > m/s$ and $r(0) =< 0,0 > m$

a) Find $\vec{r}(t)$ and rewrite it in rectangular coordinates

b) Find curvature at its maximum height

c) Find the directrix of the parabola and explain the significant of it.

d) Find the focal point of the parabola and explain the significant of it.

e) Find osculating circle at the point on its maximum height.