



## Problem 02

(a)

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In[69]:= MVVerlet[x0_, v0_, m_, q_, dt_, n_, BF_] :=
Module[{X, V, alpha, x, v, d, C, j},
  X = Table[0., {i, 1, n}];
  X[[1]] = x0;
  V = Table[0., {i, 1, n}];
  V[[1]] = v0;
  x = x0;
  v = v0;
  alpha = q dt / (2 m);
  For[j = 2, j ≤ n, j = j + 1,
    d = v + alpha Cross[v, BF[x]];
    x = x + d dt;
    C = BF[x];
    v = (d + alpha Cross[d, C]
      + alpha^2 C d.C) / (1 + alpha^2 C.C);
    X[[j]] = x;
    V[[j]] = v;
  ];
  Return[{X, V}];
];

ShowTrajectory[pts_] :=
Show[Graphics3D[Table[Line[{pts[[jj]], pts[[jj + 1]]}], {jj, 1, Length[pts] - 1}]]]

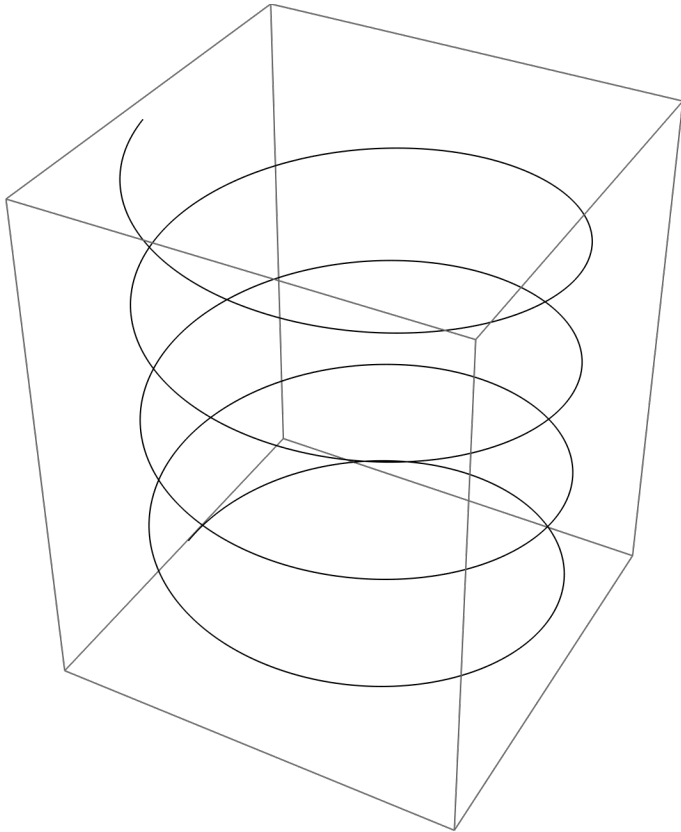
BFA[x_] := {0, 0, 1};
x0a = {1, 0, 0};
v0a = {0, 1, 0.1};

{Xa, Va} = MVVerlet[x0a, v0a, 1, 1, 0.005, 5000, BFA];

ShowTrajectory[Xa]

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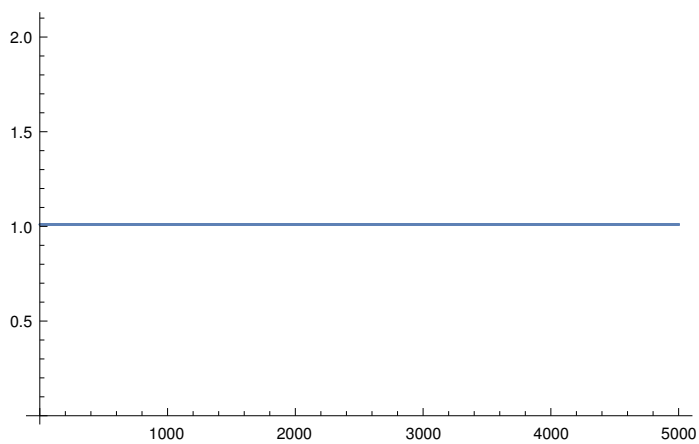
Out[75]=



(b)

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In[76]:= vsquared = Table[Va[[jj]].Va[[jj]], {jj, 1, Length[Va]}];  
ListPlot[vsquared]
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Out[77]=



(c)

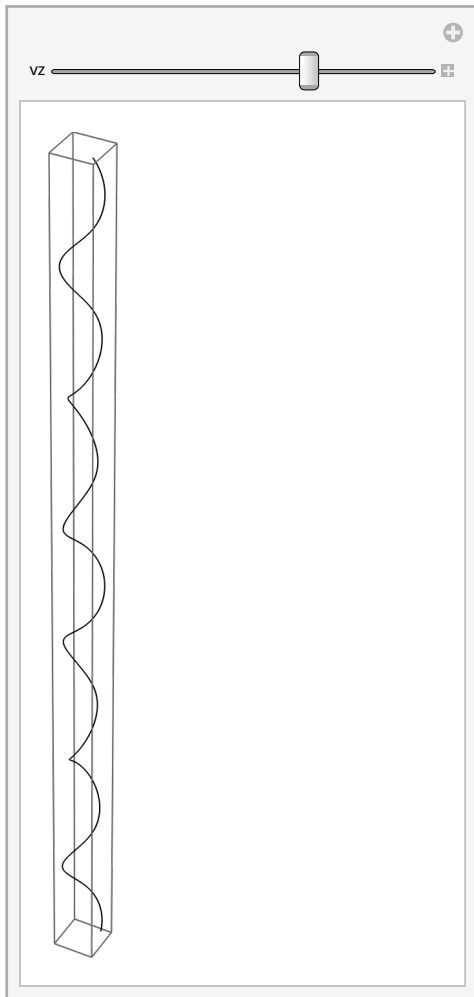
In[82]:=

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BFc[{x_, y_, z_}] := {(-y)/(x^2 + y^2), (x)/(x^2 + y^2), 0}
Manipulate[
  Module[{Xc, Vc, x0c, v0c},
    (*Initial conditions for vz variance*)
    x0c = {1, 0, 0};
    v0c = {0, 1, vz};
    {Xc, Vc} = MVerlet[x0c, v0c, 1, 1, 0.005, 5000, BFc];
    (*Plot the trajectory with slider for initial vz*)
    ShowTrajectory[Xc],
    {vz, -5, 5, 0.05}]
  (*Increasing the Vz shows the path becomes increasingly helical*)

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Out[83]=



(d)

In[84]:=

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x0d = {1, 0, 0};  
v0d = {0.5, 0.5, 0};  
{Xd, Vd} = MVVerlet[x0d, v0d, 1, 1, 0.005, 5000, BFc];  
ShowTrajectory[Xd]
```

Out[87]=

