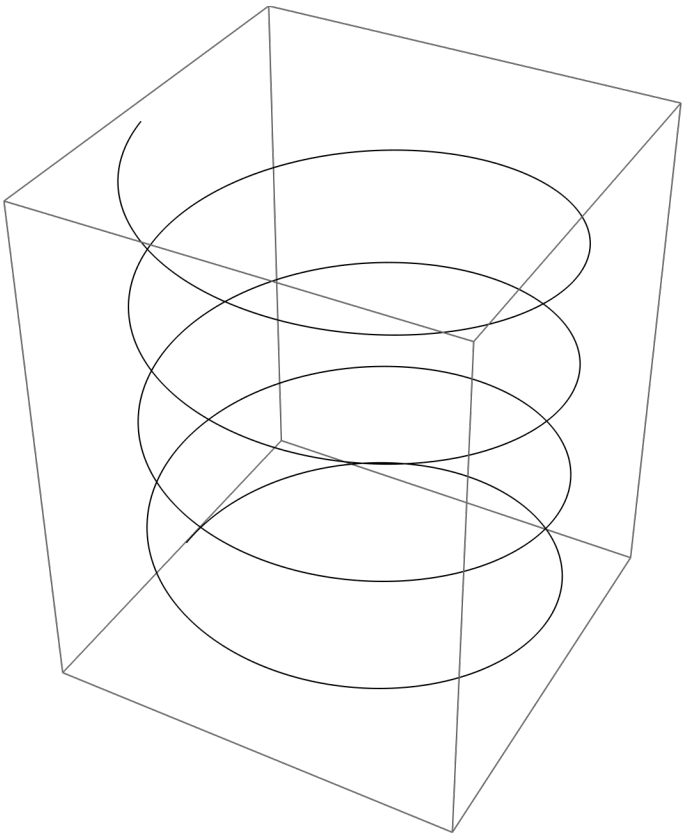
Problem 02

(a)

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]
```

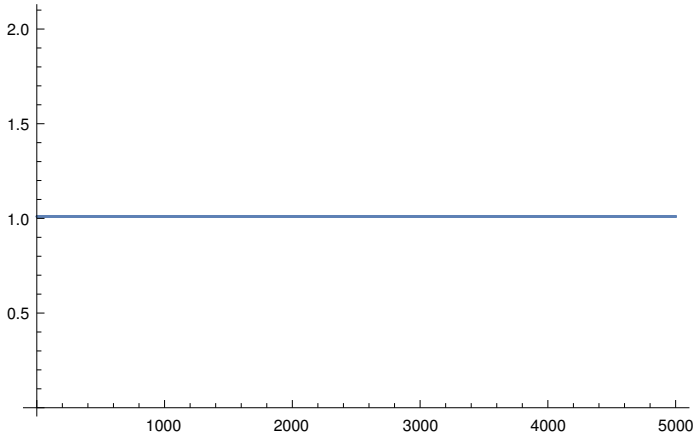
Out[75]=



(b)

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

Out[77]=

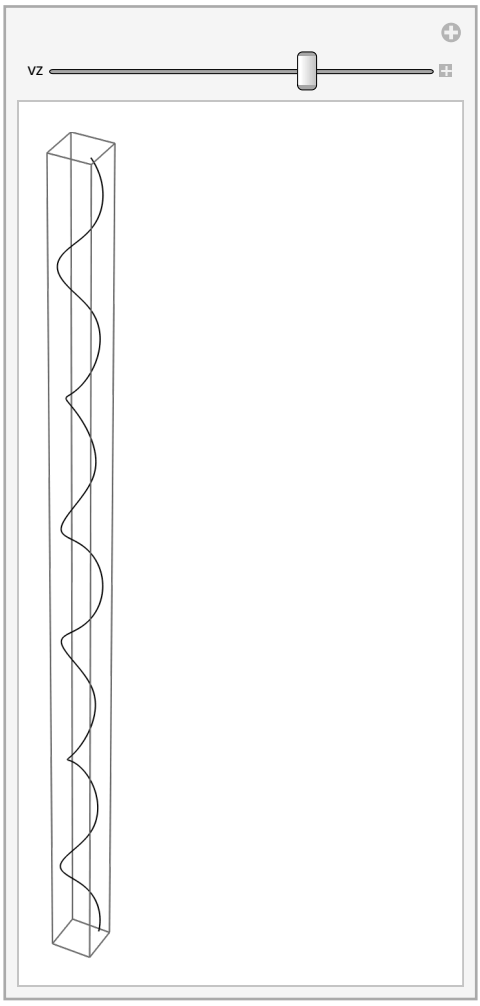


(c)

In[82]:=

```
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} = MVVerlet[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*)
```

Out[83]=



(d)

In[84]:=

```
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]=