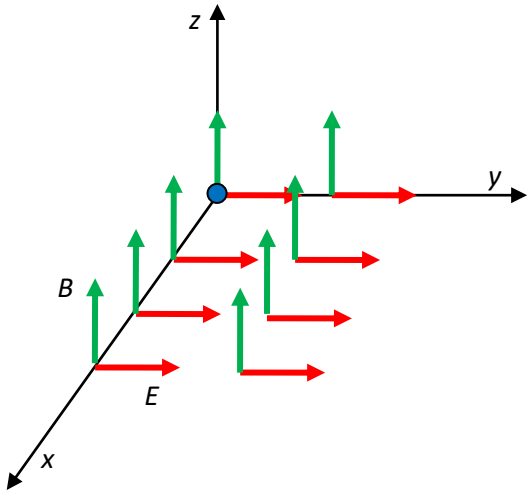
Teacher notes
Topic D

A qualitative problem: motion in crossed *E* and *B* fields.

Suppose that we place a positive charge at the origin of a coordinate system. There is a constant electric field directed parallel to the *y*-axis everywhere and a constant magnetic field parallel to the *z*-axis everywhere.



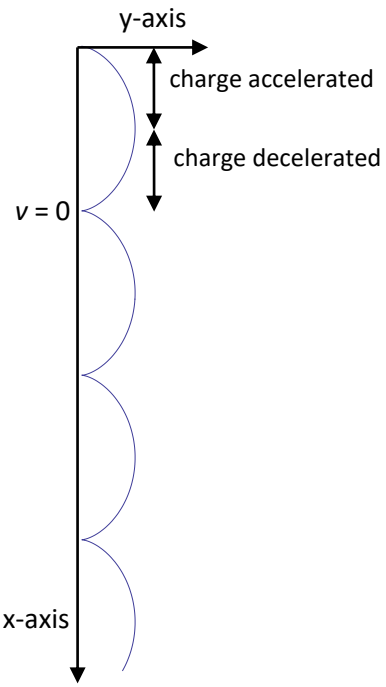
Without solving any equations, **qualitatively** discuss the path followed by the charge when it is released from rest at the origin, giving as much detail as you can.

Initially, the speed is zero so there is only an electric force directed along the *y*-axis. The charge will then start moving along the *y*-axis.

As soon as the charge begins to move it will experience a magnetic force directed towards the *x*-axis and so the charge will start bending towards the *x*-axis.

At some point, the velocity of the charge will be parallel to the *x*-axis. At this point, the speed of the charge reaches a maximum because it has been accelerated by the electric field (work done by the field is positive). Past this point the electric field will be decelerating the charge (work done by the field is negative) and by the time the charge reaches the x-axis the speed will be zero (because the positive work done during acceleration is equal and opposite to the negative work during deceleration).

The above process will then repeat. This gives the path on the *x*-*y* plane as shown.



You may want to investigate the analytic solution to this problem; it is not beyond the abilities of a HL math student. You will meet some really nice math and you will be introduced to a wonderful curve called the cycloid.