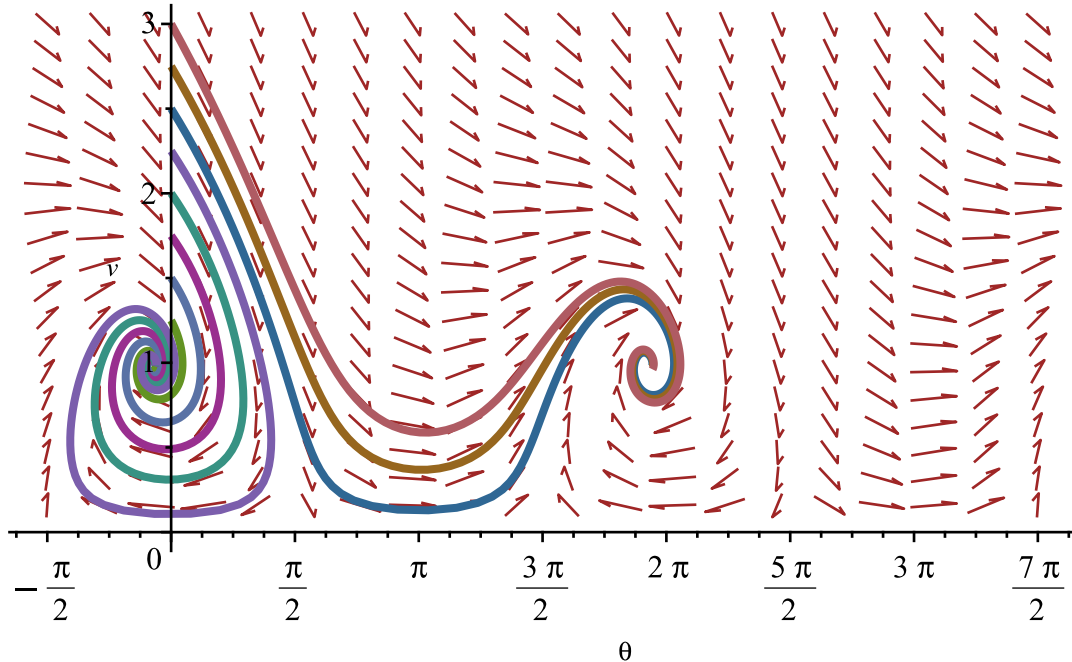


March 19, 2024 -- Happy first day of spring!

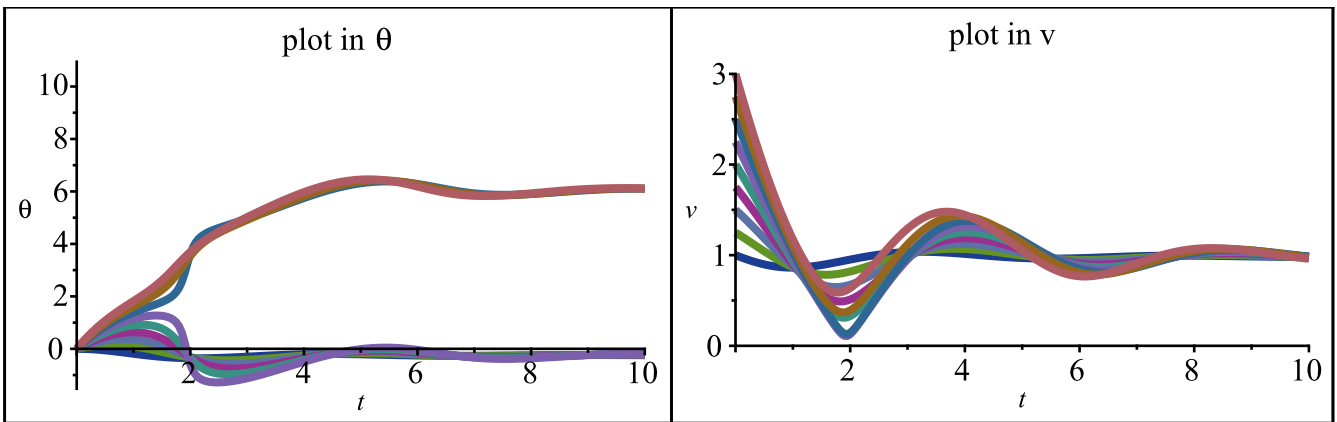
```
> phug:=[D(theta)(t)=v(t)- cos(theta(t))/v(t),  
         D(v)(t)=-sin(theta(t))-R*v(t)^2 ];  
phug := [ D(theta)(t) = v(t) - \frac{\cos(\theta(t))}{v(t)}, D(v)(t) = -\sin(\theta(t)) - Rv(t)^2 ] (1)
```

```
> with(DEtools):  
> inits:=[seq([v(0)=1+.25*i,theta(0)=0], i=0..8)]:  
> R:=0.25;  
R:= 0.25 (2)
```

```
> DEplot(phug,[theta(t),v(t)],t=0..10, inits,  
         theta=-Pi/2..7*Pi/2, v=0..3, stepsize=0.05,  
         tickmarks=[piticks,default], size=[.8,"golden"]);
```



```
> plots[display](  
  DEplot(phug,[theta(t),v(t)],t=0..10, inits,  
         theta=-Pi/2..7*Pi/2, v=0..3, stepsize=0.05,  
         size=[.8,"golden"],  
         scene=[t,theta], title=typeset("plot in ",theta))  
  | DEplot(phug,[theta(t),v(t)],t=0..10, inits,  
         theta=-Pi/2..7*Pi/2, v=0..3, stepsize=0.05,  
         size=[.8,"golden"], title="plot in v" ,  
         scene=[t,v]) >);
```

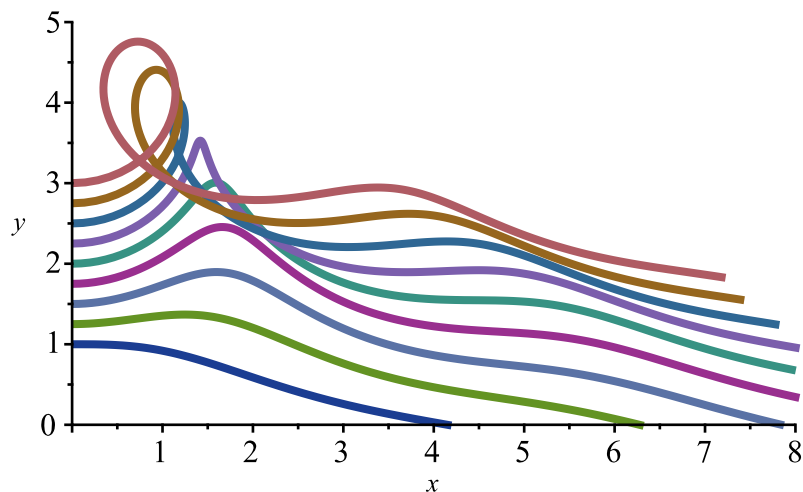


```
> xphug:=[op(phug), D(x)(t)=v(t)*cos(theta(t)),
          D(y)(t)=v(t)*sin(theta(t))]
```

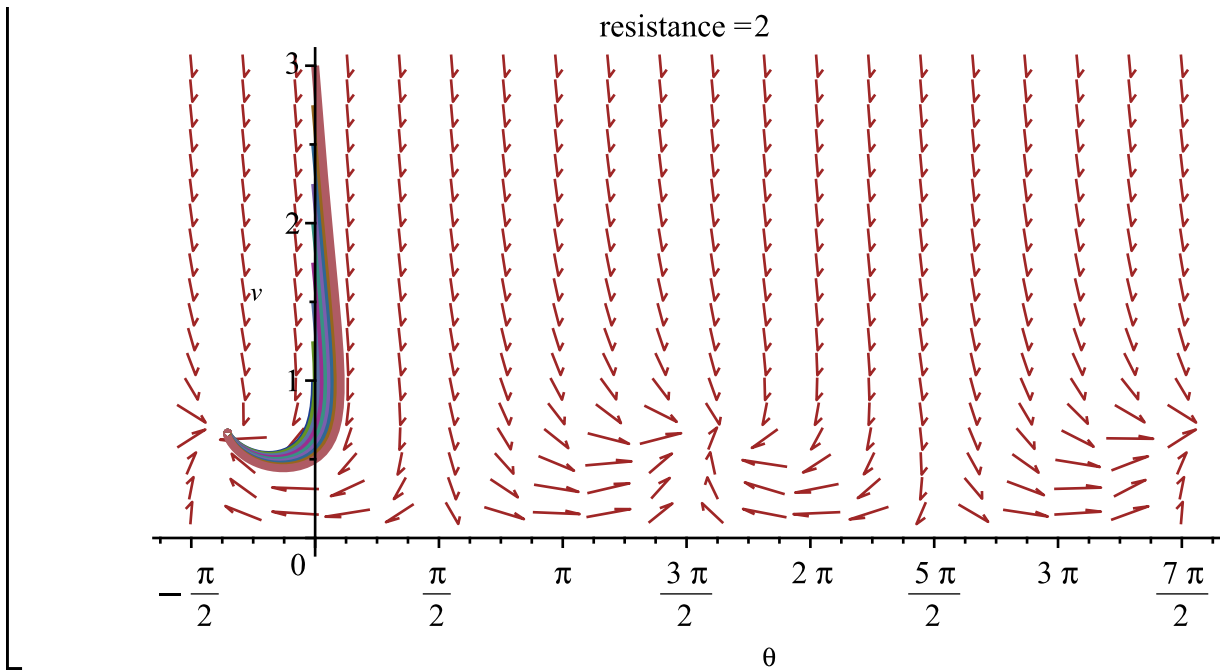
```
xphug := [ D(theta)(t) = v(t) - \frac{\cos(\theta(t))}{v(t)}, D(v)(t) = -\sin(\theta(t)) - 0.25 v(t)^2, D(x)(t)
          = v(t) \cos(\theta(t)), D(y)(t) = v(t) \sin(\theta(t)) ] (3)
```

```
> xinit:=[seq([v(0)=1+.25*i,theta(0)=0, x(0)=0, y(0)=1+i/4], i=0..8)]:
```

```
> DEplot(xphug,[theta(t),v(t),x(t),y(t)],t=0..10, xinit,
         theta=-Pi/2..7*Pi/2, v=0..3, x=0..8, y=0..5,stepsize=0.05,
         scene=[x,y],
         size=[.6,"golden"]);
```



```
> R:=2;
DEplot(phug,[theta(t),v(t)],t=0..10, inits,
      theta=-Pi/2..7*Pi/2, v=0..3, stepsize=0.05,
      title=(typeset("resistance =",R)),
      tickmarks=[piticks,default], size=[.8,"golden"]);
R:=2
```



```
> R:=.25;
                                     R:= 0.25
```

(4)

```
> solve( { v-cos(theta)/v=0, sin(theta)-R*v^2=0 } );
{theta=0.2449786631, v=0.9849581210}, {theta=0.2449786631, v=-0.9849581210}, {theta
=-2.896613990, v=0.9849581210 I}, {theta=-2.896613990, v=-0.9849581210 I}
```

(5)