```
> with(DEtools):
> D(sin);
```

$$\cos \tag{1}$$

```
> diff(sin(x),x);
```

$$\cos(x) \tag{2}$$

```
> D(sin)(t);
```

$$\cos(t) \tag{3}$$

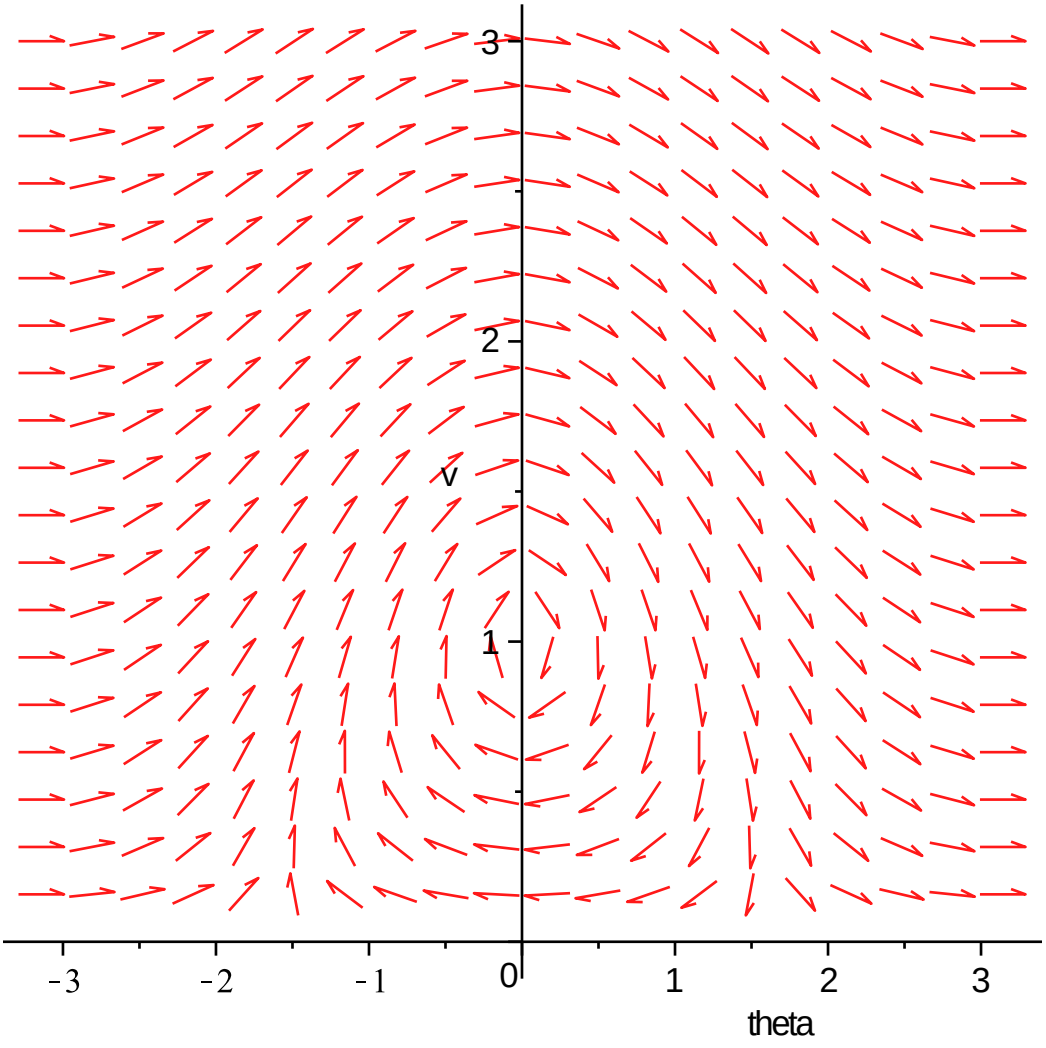
```
> D(sin)(Pi/4);
```

$$\frac{1}{2}\sqrt{2} \tag{4}$$

```
> phug:=[ D(theta)(t) = v(t) - cos(theta(t))/v(t),
        D(v)(t)     = -sin(theta(t))];
```

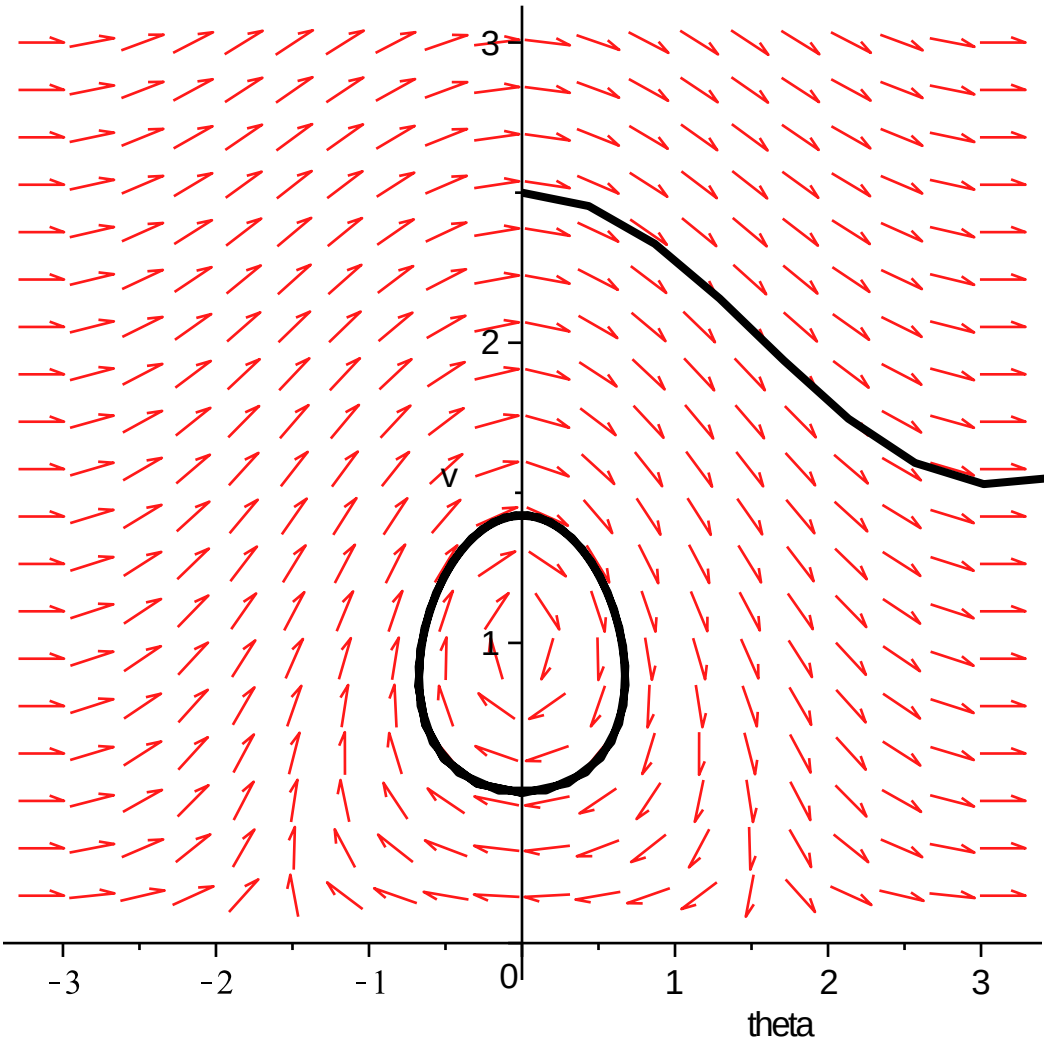
$$phug := \left[D(\theta)(t) = v(t) - \frac{\cos(\theta(t))}{v(t)}, D(v)(t) = -\sin(\theta(t)) \right] \tag{5}$$

```
> DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3);
```

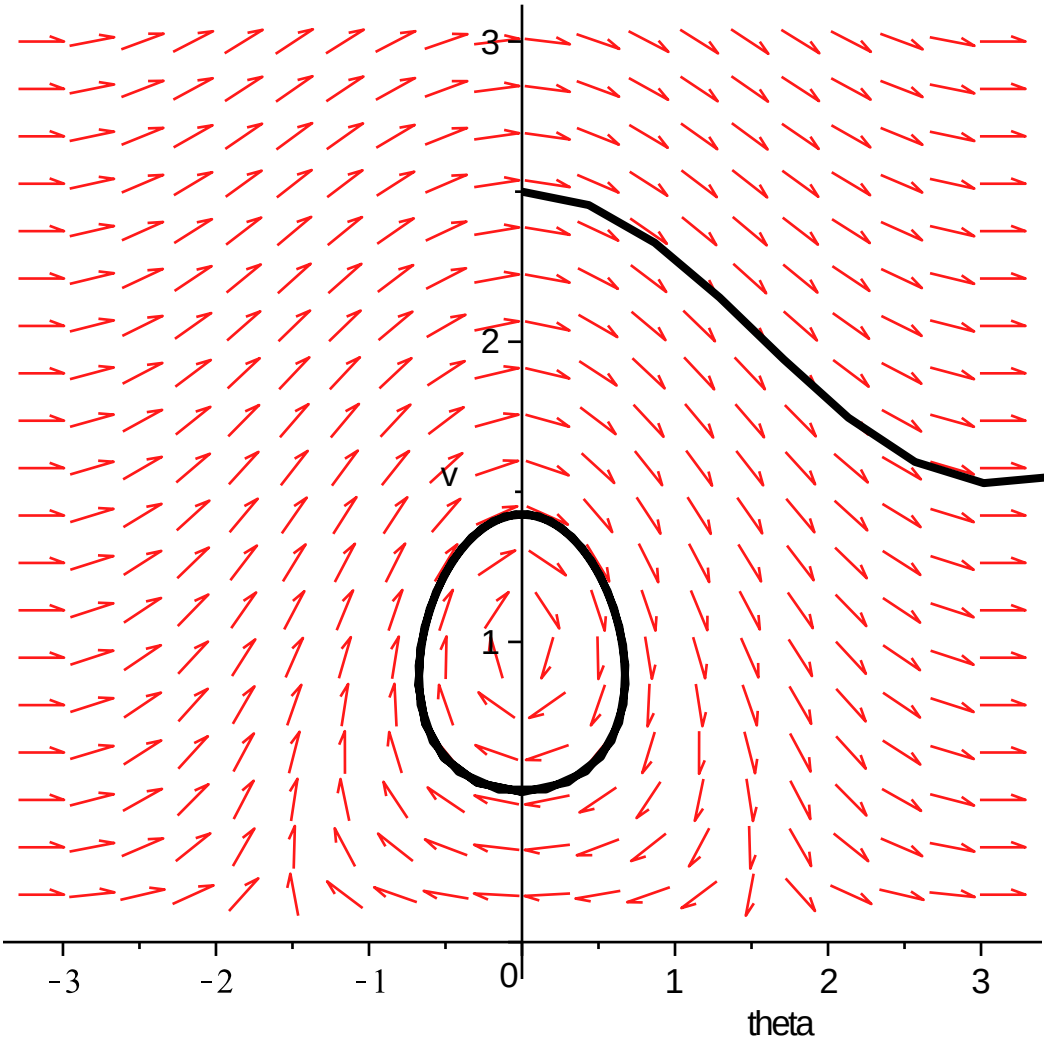



```
> DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3,
    [[theta(0)=0, v(0)=2.5], [theta(0)=0, v(0)=0.5]],
```

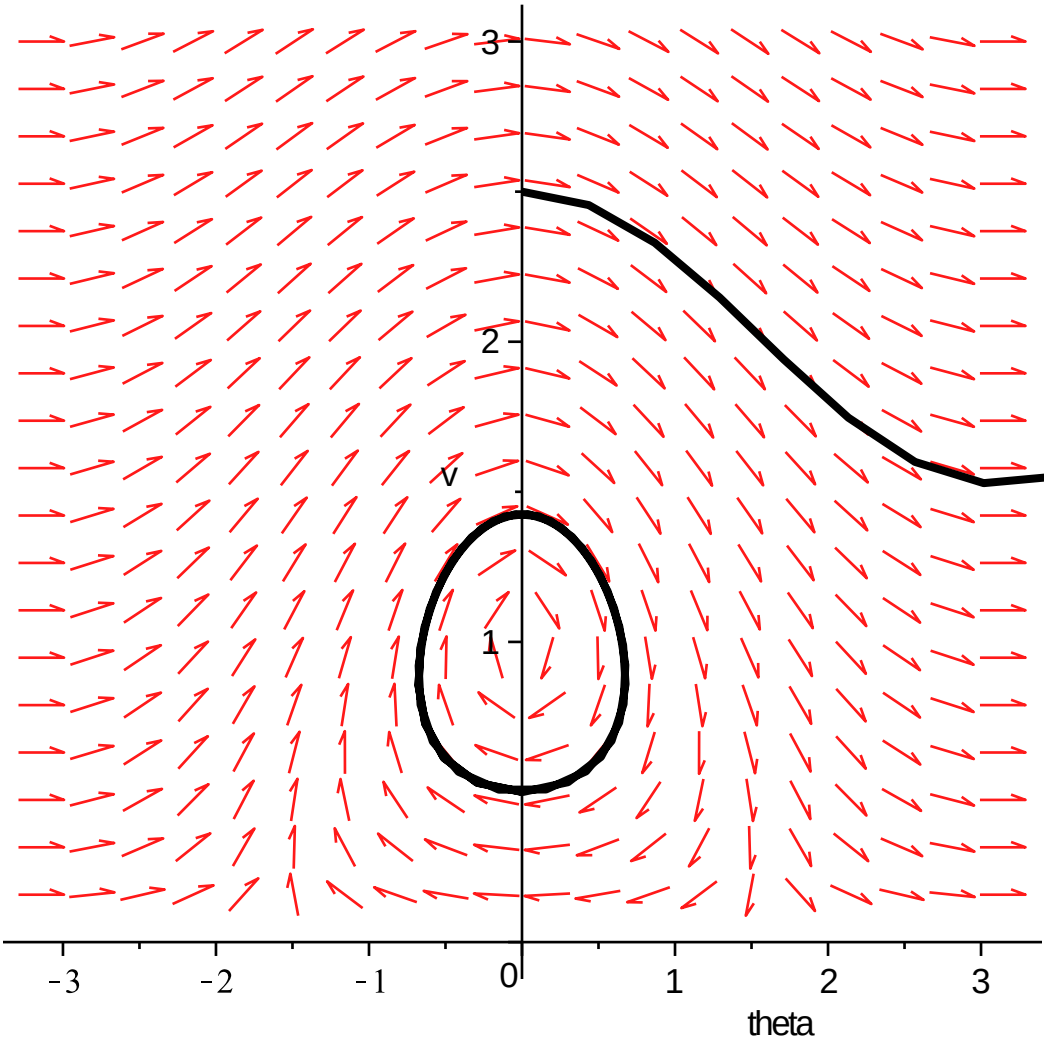
```
linecolor=black) ;
```



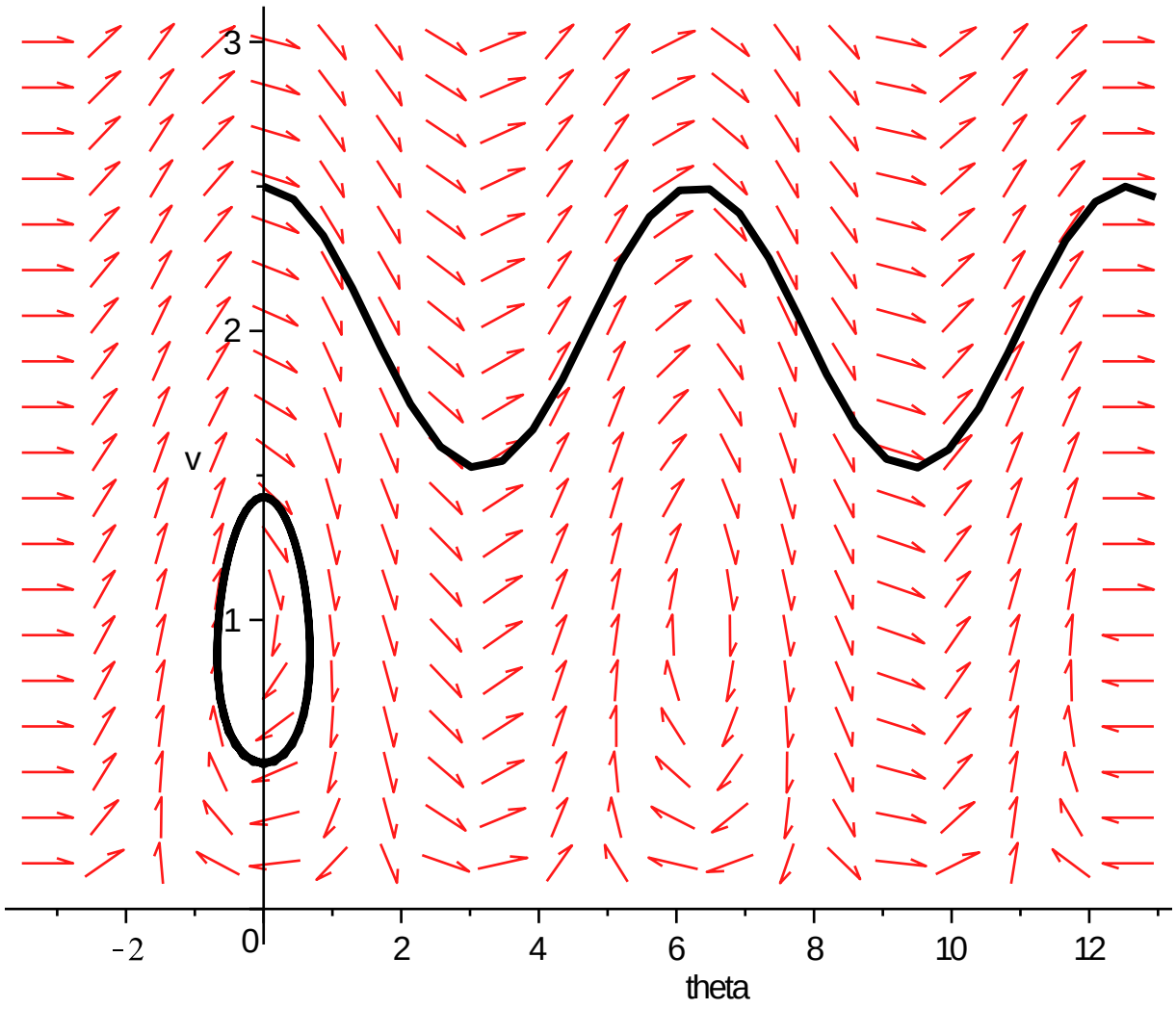

```
> DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3,
    [[theta(0)=0, v(0)=2.5], [theta(0)=0, v(0)=0.5]],
    linecolor=black);
```



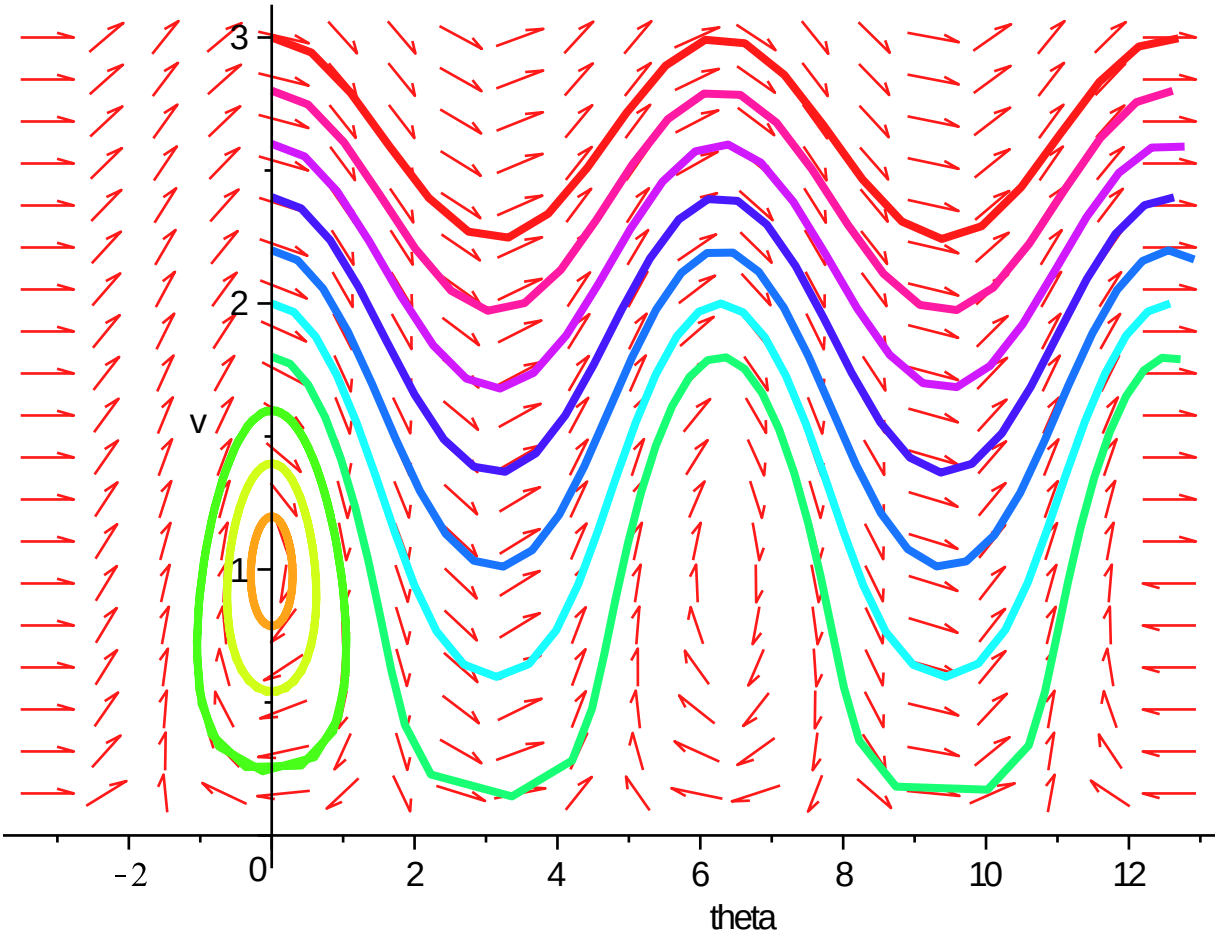

```
> DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3,
    [[theta(0)=0, v(0)=2.5], [theta(0)=0, v(0)=0.5]],
    linecolor=black);
```




```
> DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [[theta(0)=0, v(0)=2.5], [theta(0)=0, v(0)=0.5]],
    linecolor=black);
```




```
> DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)]);
```



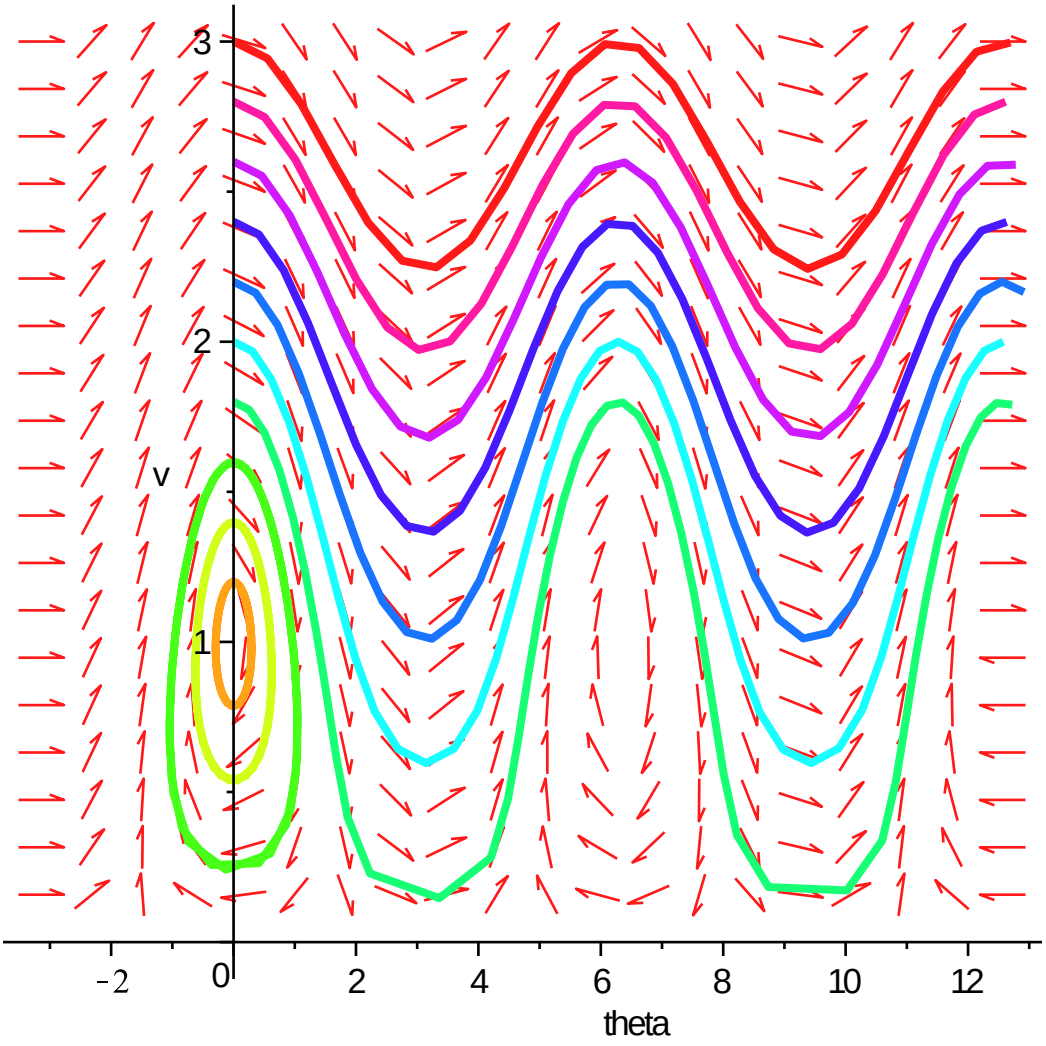

```
> phug:=[ D(theta)(t) = v(t) - cos(theta(t))/v(t),
        D(v)(t)     = -sin(theta(t))-R*v(t)^2];
```

$$phug := \left[\mathrm{D}(\theta)(t) = v(t) - \frac{\cos(\theta(t))}{v(t)}, \mathrm{D}(v)(t) = -\sin(\theta(t)) - R\,v(t)^2 \right] \quad (6)$$

```
> R:=0;
  phase0:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)]);
  phase0;
```

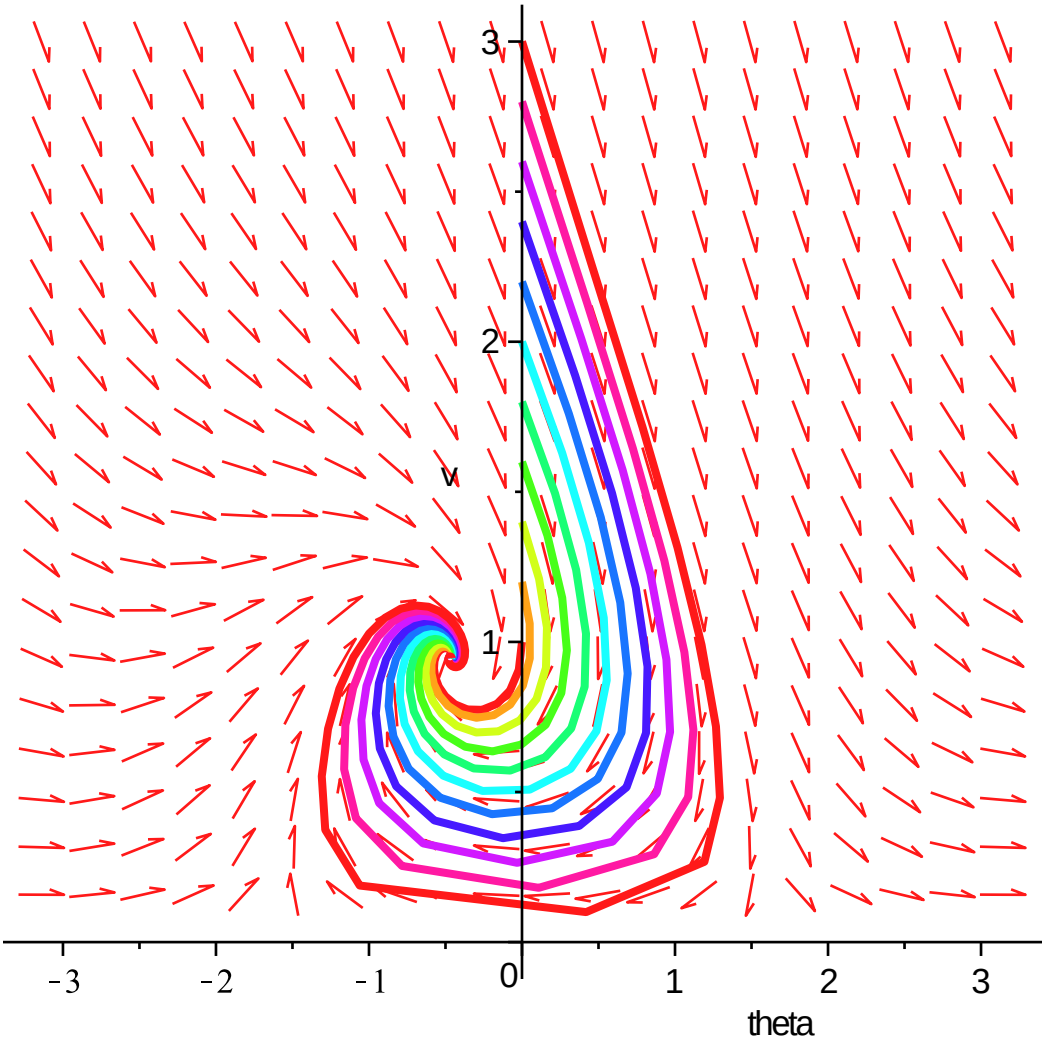
$$R := 0$$

$$phase0 := PLOT(\ldots)$$




```
> R:=0.5;
  DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)]);
```

$$R := 0.5$$




```
> R:=0;
  thet0:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,theta]);
```

$$R := 0$$

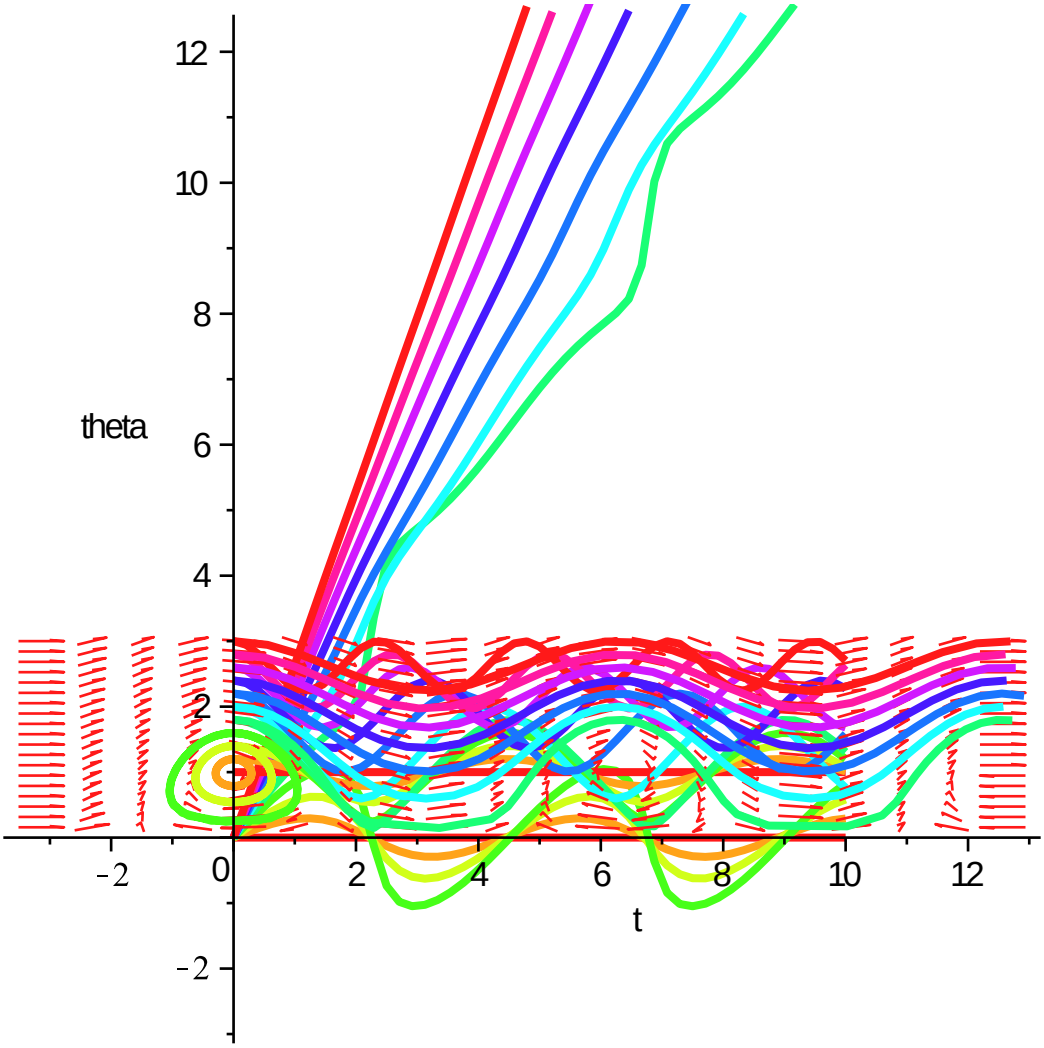
$$thet0 := PLOT(\ldots) \qquad (7)$$

```
> R:=0;
  v0:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,v]);
```

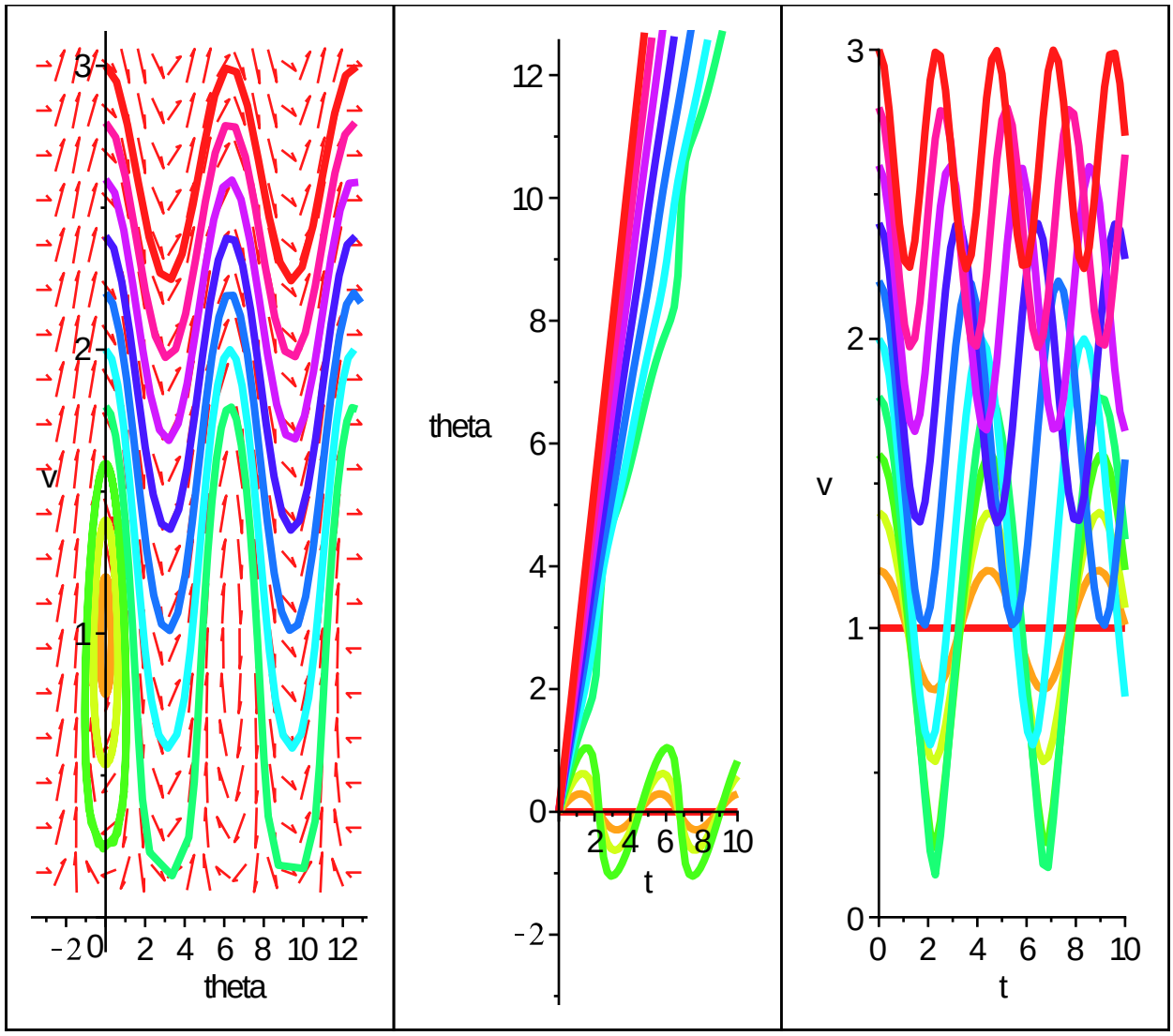
$$R := 0$$

$$v0 := PLOT(\ldots) \qquad (8)$$

```
> with(plots):
> display({phase0, thet0, v0});
```

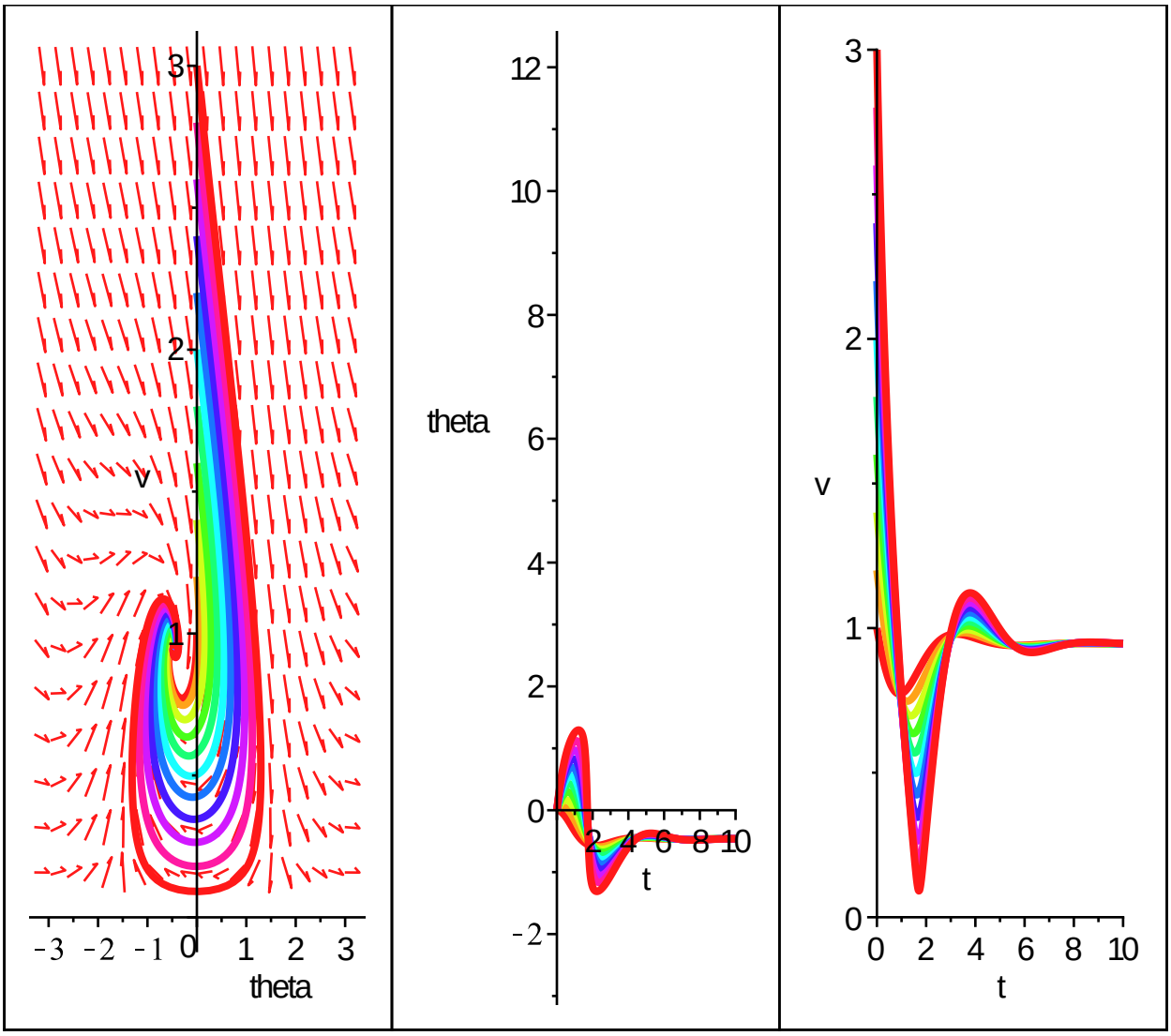



```
> display(array([phase0, thet0, v0]));
```



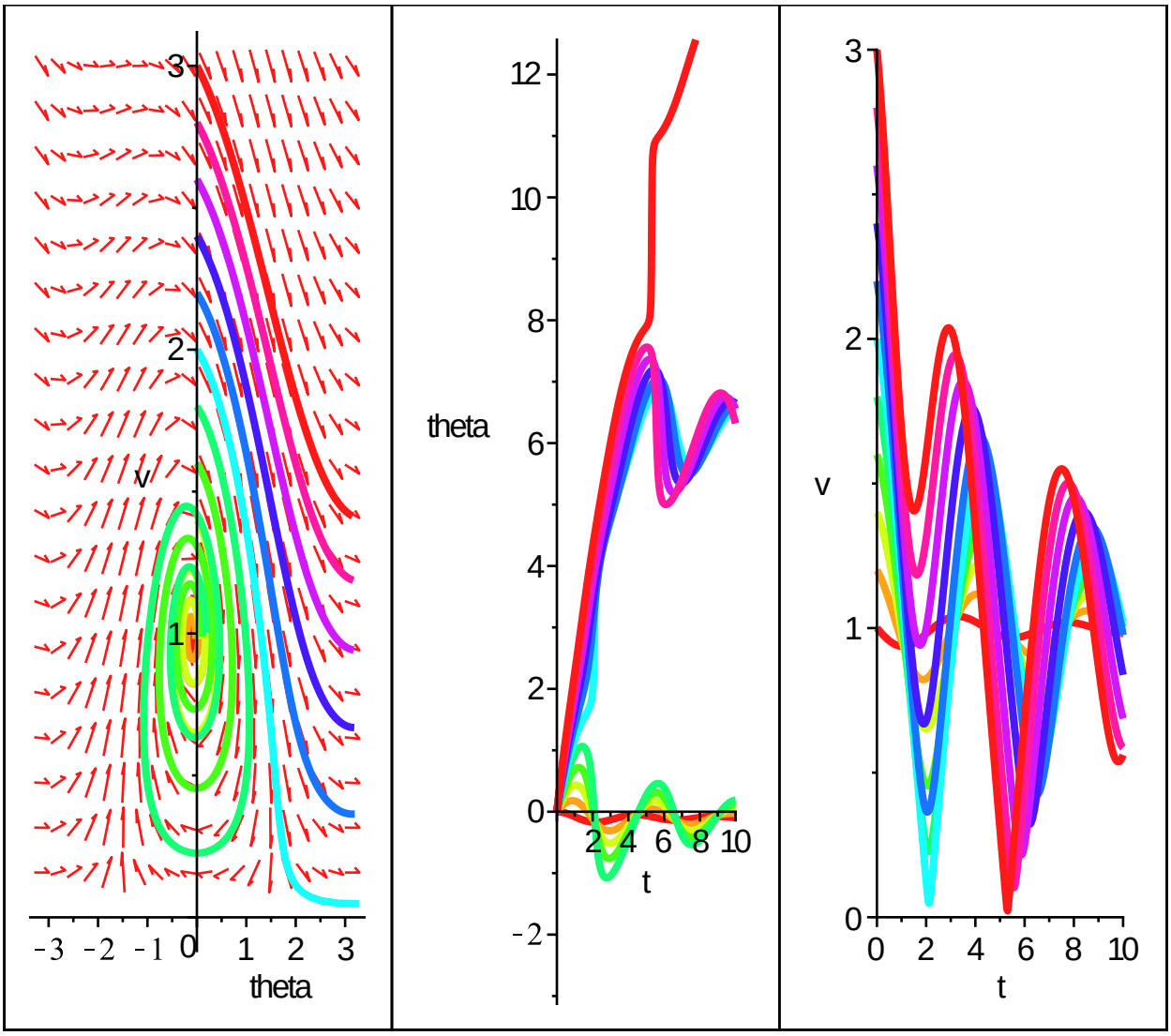

```
> R:=0.5;
  A:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[theta,v], numpoints=500):
  B:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,theta], numpoints=500) :
  C:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,v], numpoints=500) :
  display(array([A,B,C]));
```

$$R := 0.5$$



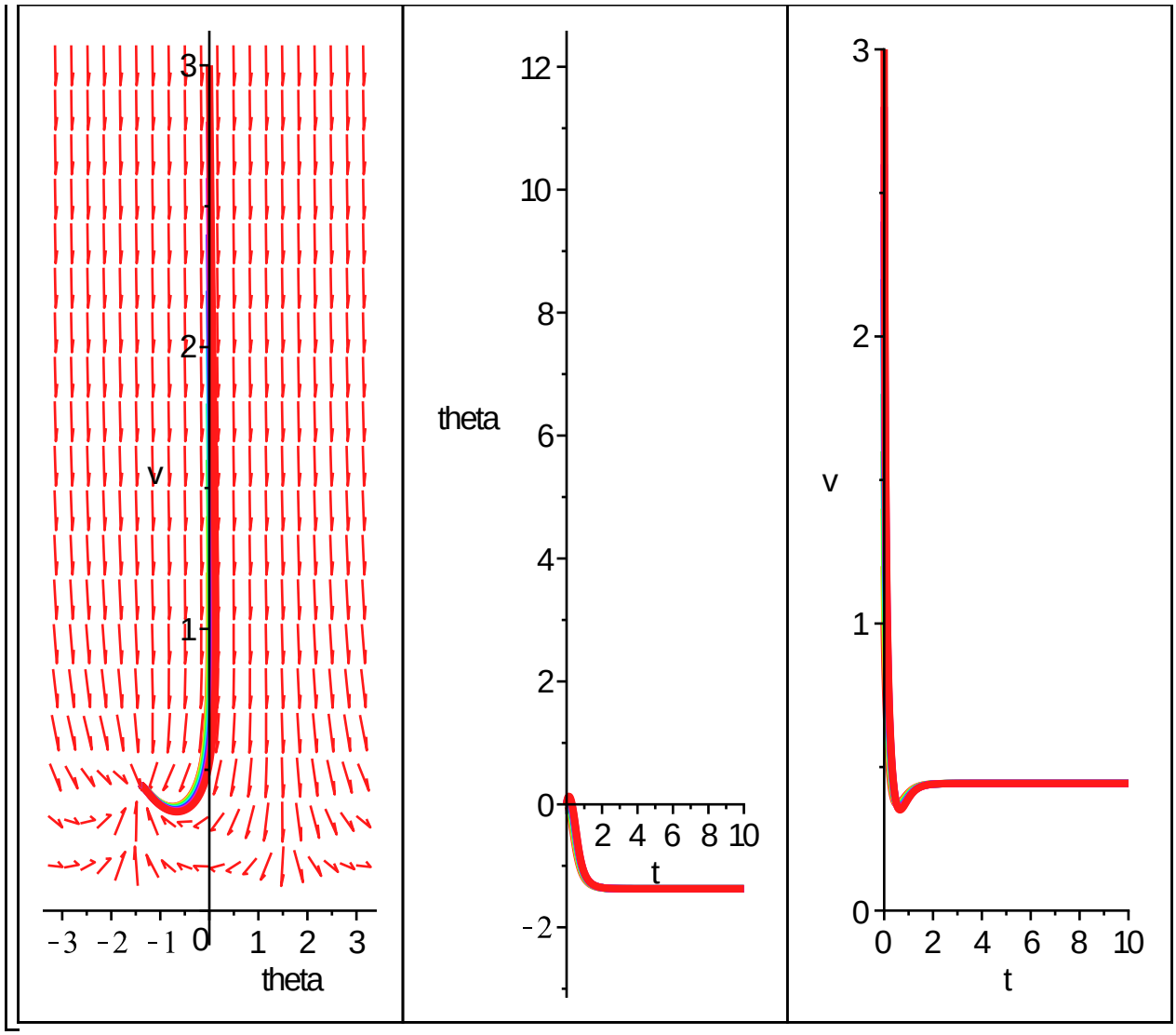

```
> R:=0.1;
  A:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[theta,v], numpoints=500):
  B:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,theta], numpoints=500):
  C:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,v], numpoints=500):
  display(array([A,B,C]));
```

$$R := 0.1$$




```
> R:=5;
  A:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[theta,v], numpoints=500):
  B:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,theta], numpoints=500):
  C:=DEplot( phug, [theta(t), v(t)], t=0..10,
    theta=-Pi..4*Pi, v=0..3,
    [seq([theta(0)=0, v(0)=i],i=1..3,0.2)],
    linecolor=[seq(COLOR(HUE,i),i=0..1,.1)],
    scene=[t,v], numpoints=500):
  display(array([A,B,C]));
```

$$R := 5$$


3
2
1
v
-3 -2 -1 0 1 2 3
theta
12
10
8
6
4
2
0
-2
theta
2 4 6 8 10
t
3
2
1
0
v
0 2 4 6 8 10
t