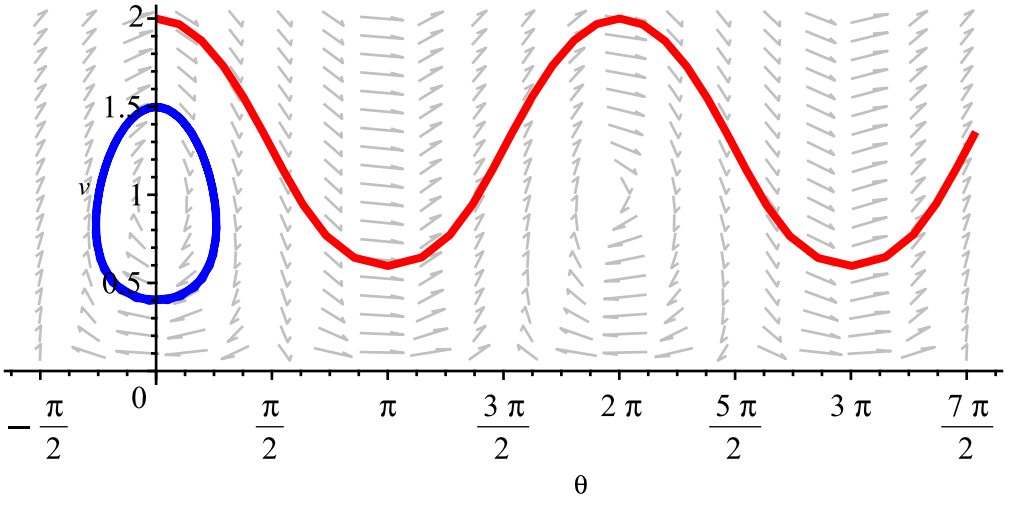
March 5, 2024

More Phugoid stuff.

$$\frac{d}{dt}\,\theta(t) = v(t) - \frac{\cos(\theta(t))}{v(t)} \;;\; \left(\frac{d}{dt}\,v(t)\right) = -\sin(\theta(t)) - R(v(t))^2$$

```
> with(DEtools):
> phug := [D(theta)(t) = v(t) - cos(theta(t))/v(t), D(v)(t) = -sin(theta(t)) - R(v(t))^2]:
> R := 0;
  DEplot(phug, [theta(t), v(t)], t = 0..10,
  [[theta(0) = 0, v(0) = 1.5], [theta(0) = 0, v(0) = 2]],
  theta = -Pi/2..7*Pi/2, v = 0..2,
  tickmarks = [piticks, default], size = [.75, .5], linecolor = [blue, red], color = gray);
```

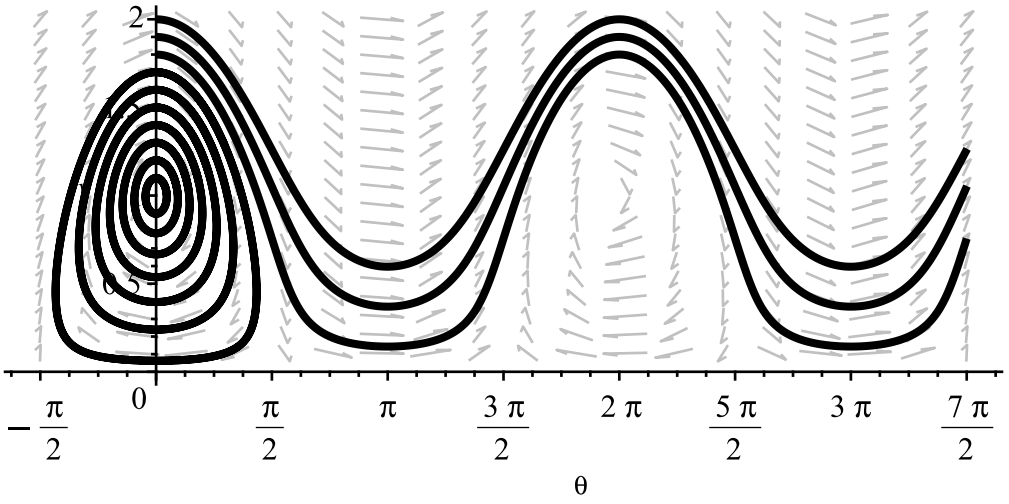
$R := 0$




```
> R := 0;
  local v0;
  DEplot(phug, [theta(t), v(t)], t = 0..10,
  [seq([theta(0) = 0, v(0) = v0], v0 = 1..2, .1)],
  theta = -Pi/2..7*Pi/2, v = 0..2, stepsize = .01,
  tickmarks = [piticks, default], size = [.75, .5], linecolor = black, color = gray);
```

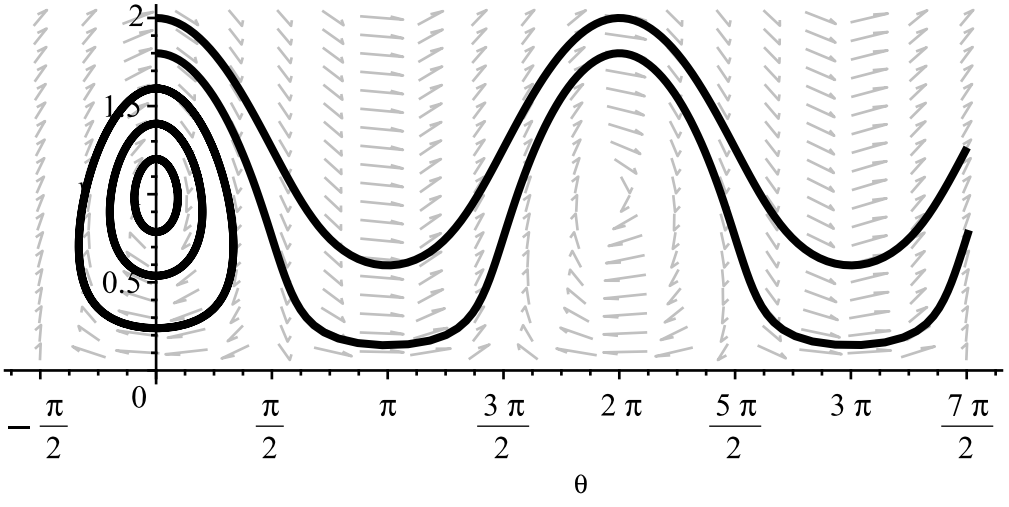
$R := 0$

$v0$




```
> R := 0 :
  local v0 :
  local nsols := 5 : # how many solution curves I want to see
  DEplot( phug, [theta(t), v(t)], t = 0..10,
  [ seq( [theta(0) = 0, v(0) = v0], v0 = 1..2, 1.0/nsols ) ],
  theta = -Pi/2 .. 7*Pi/2, v = 0..2, stepsize = 0.05,
  # stepsize controls roughness of solution, smaller is more computation but smoother picture.
  tickmarks = [piticks, default], size = [.75, .5], linecolor = black, color = gray );
```

nsols




```
> R := 0 :
  local v0 :
  local nsols := 5 : # how many solution curves I want to see
  DEplot( phug, [theta(t), v(t)], t = 0..10,
```

$$\left[seq\left(\left[\text{theta}(0)=0,\ v(0)=v0\right],\ v0=1..2,\ \frac{1.0}{nsols}\right)\right],$$

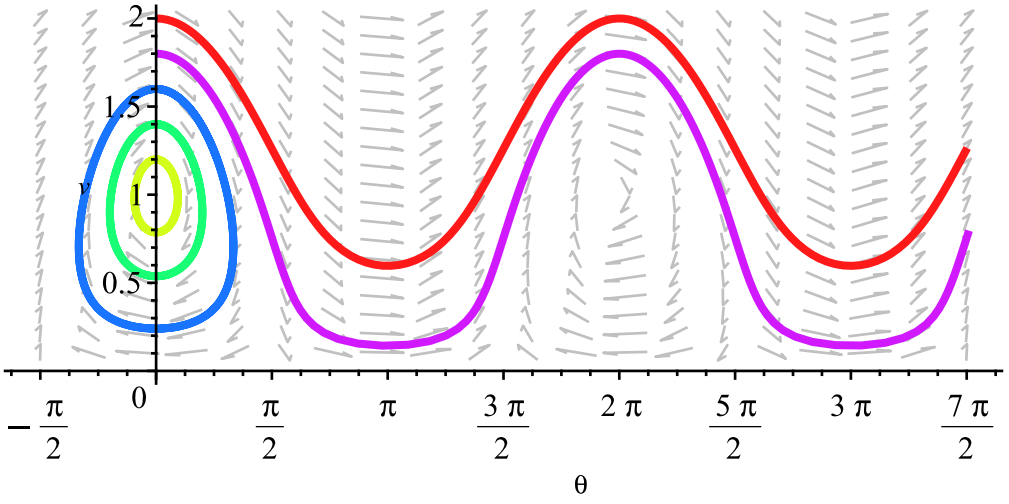
$$\text{theta}=-\frac{\text{Pi}}{2}..\frac{7\cdot\text{Pi}}{2},\ v=0..2,\ stepsize=0.05,$$

 # stepsize controls roughness of solution, smaller is more computation but smoother picture.

$$tickmarks=[piticks,\ default],\ size=[.75,\ .5],$$

$$linecolor=\left[seq\left(COLOR(HUE,\ t),\ t=0..1,\ \frac{1.0}{nsols}\right)\right],\ color=gray\Big);$$

nsols




```
> gliderpic := proc(R, nsols := 10)
  local v0, t, h :
  local theta, v, pic;
  local phug;
```

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

$$pic:=DEplot\Big(phug,\ [\text{theta}(t),\ v(t)],\ t=0..10,$$

$$\left[seq\left(\left[\text{theta}(0)=0,\ v(0)=v0\right],\ v0=1..2,\ \frac{1.0}{nsols}\right)\right],$$

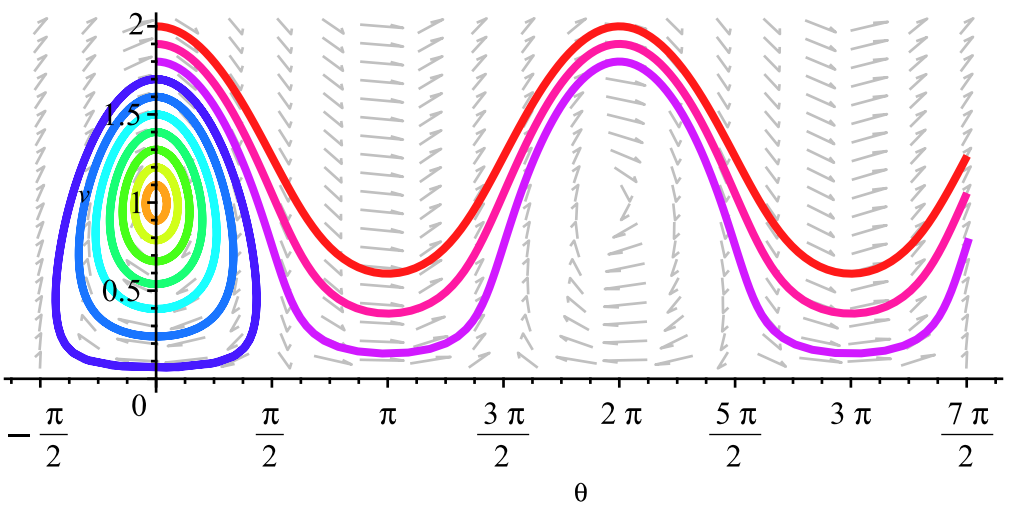
$$\text{theta}=-\frac{\text{Pi}}{2}..\frac{7\cdot\text{Pi}}{2},\ v=0..2,\ stepsize=0.05,$$

 # stepsize controls roughness of solution, smaller is more computation but smoother picture.

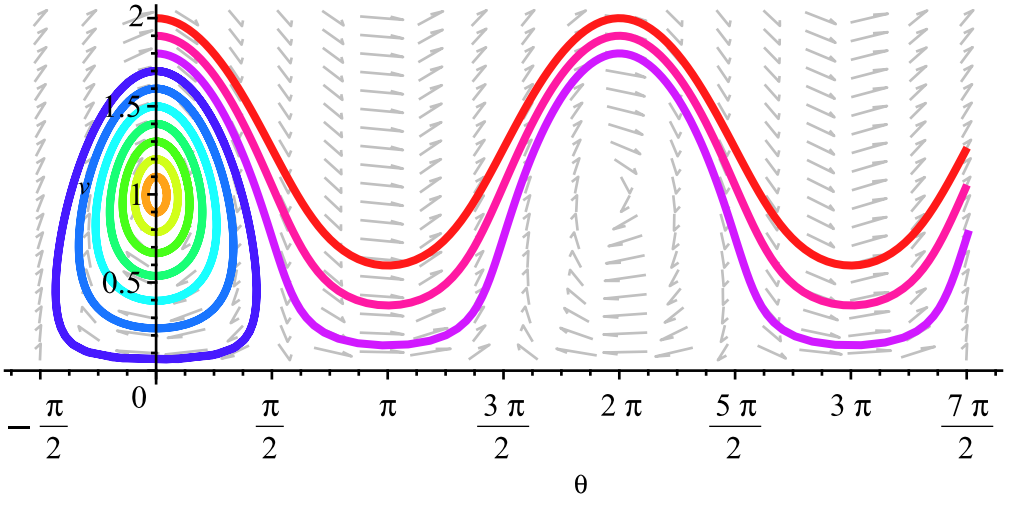
$$tickmarks=[piticks,\ default],\ size=[.75,\ .5],$$

$$linecolor=\left[seq\left(COLOR(HUE,\ h),\ h=0..1,\ \frac{1.0}{nsols}\right)\right],\ color=gray\Big);$$

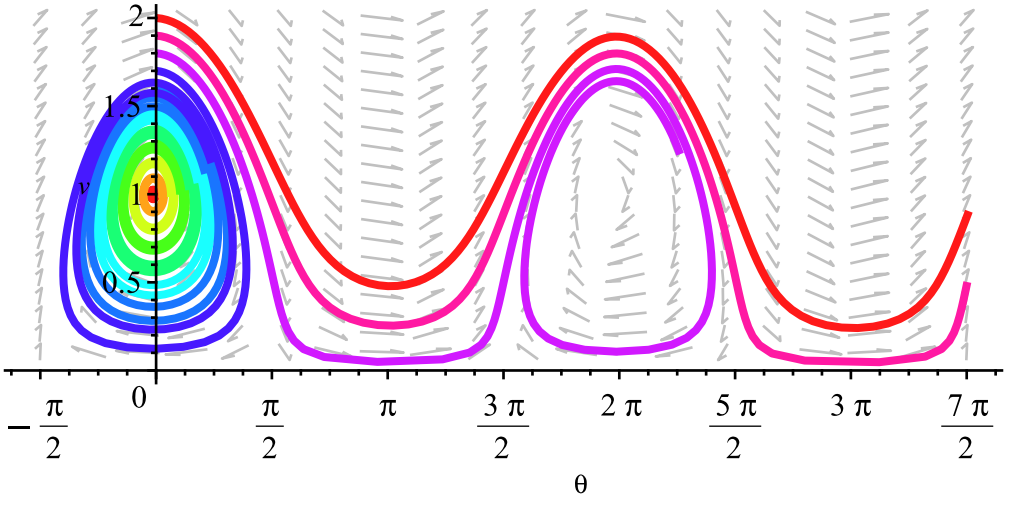
```
  return(pic);
end:
> gliderpic(0)
```



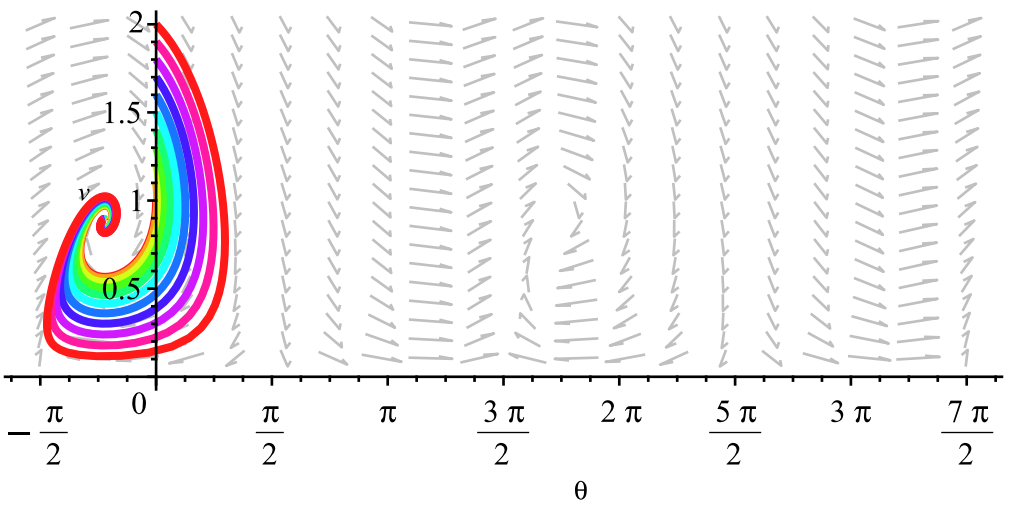
> *gliderpic*(0)



> *gliderpic*(.2)



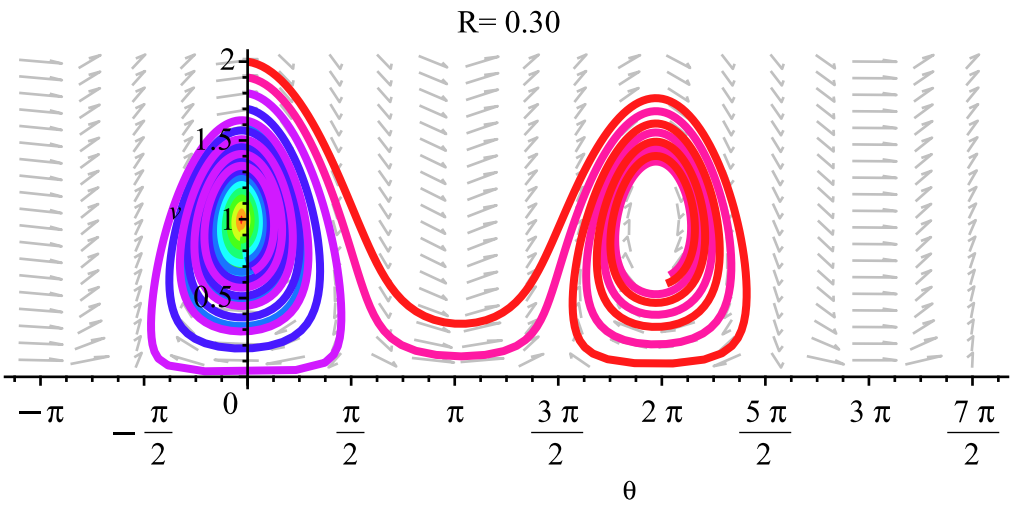
> *gliderpic*(.8)



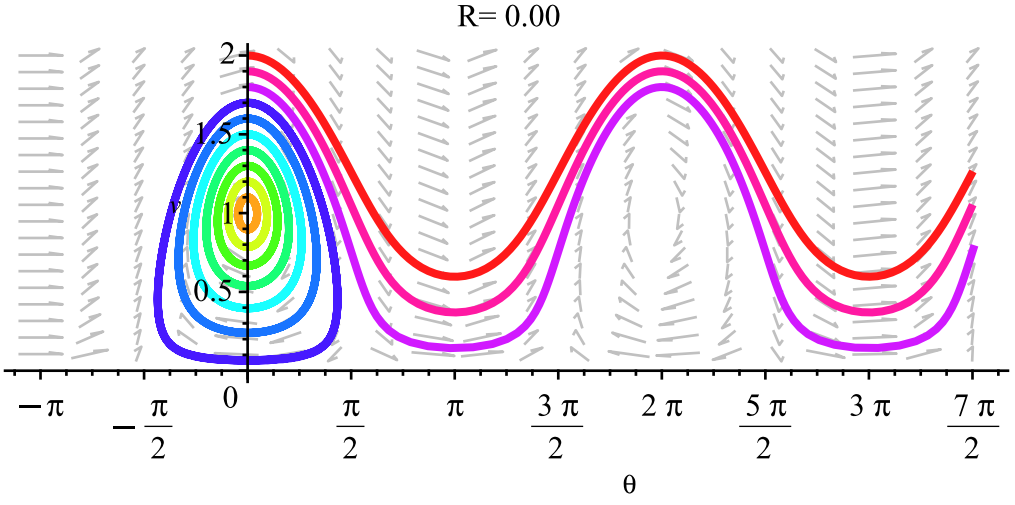

```
> gliderpic := proc(R, nsols := 10)
  local v0, t, h :
  local theta, v, pic;
  local phug;
  phug := [D(theta)(t) = v(t) - cos(theta(t))/v(t), D(v)(t) = -sin(theta(t)) - R*(v(t))^2]:
  pic := DEplot(phug, [theta(t), v(t)], t = 0..20,
  [seq([theta(0) = 0, v(0) = v0], v0 = 1..2, 1.0/nsols)],
  theta = -Pi..7*Pi/2, v = 0..2, stepsize = 0.05,

  # stepsize controls roughness of solution, smaller is more computation but smoother picture.

  tickmarks = [piticks, default], size = [.75, .5], title = sprintf("R=%5.2f", R),
  linecolor = [seq(COLOR(HUE, h), h = 0..1, 1.0/nsols)], color = gray);
  return(pic);
  end:
> gliderpic(.3)
```




```
> piclist := [seq(gliderpic(r0), r0 = 0..1, .05)]:
> plots[display](piclist, insequence = true)
    # this shows the list of pictures as a movie, controls at the top.
```




```
>
```