Lecture 13 Review

More fun with elliptical orbits (orbit.cc)

How to use multiple parameters in an ODE. (vdpol.cc)

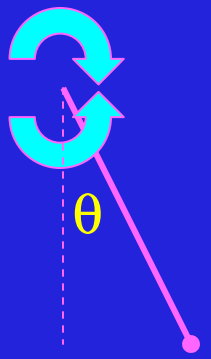
C++ `struct` structure

Intro to the logistic map $x_{i+1} = \mu x_i(1 - x_i)$

Chaotic Pendulum

Examine phase space plots (dx/dt v. x) for driven, damped pendulum.

$$\tau_g + \tau_f + \tau_{ext} = I\frac{d^2\theta}{dt^2}$$



$$-\frac{mgl}{I}\sin\theta - \frac{\beta}{I}\frac{d\theta}{dt} + \frac{\tau_0}{I}\cos\omega t = \frac{d^2\theta}{dt^2}$$

$$\frac{d^2\theta}{dt^2} = -\omega_0^2\sin\theta - \alpha\frac{\theta}{dt} + f\cos\omega t$$

Verify oscillation of free pendulum. Plot x(t) v. t; Plot dx/dt v. x.

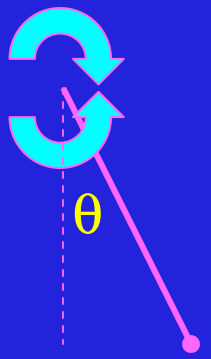
Similar to HW.

Choose $w_0^2 = 1$

Chaotic Pendulum (2)

Examine phase space plots (dx/dt v. x) for driven pendulum

$$\frac{d^2\theta}{dt^2} = \omega_0^2 \sin\theta - \alpha\frac{\theta}{dt} + f\cos\omega t$$



- Consider damped pendulum (f =0.) Plot x(t) v. t; Plot dx/dt v. x.
  Plot x(t) v. t; Plot dx/dt v. x.

  Choose $w_0^2 = 1$
  Choose $\alpha = 0.2$

- Consider damped and driven pendulum.
  Plot x(t) v. t; Plot dx/dt v. x.

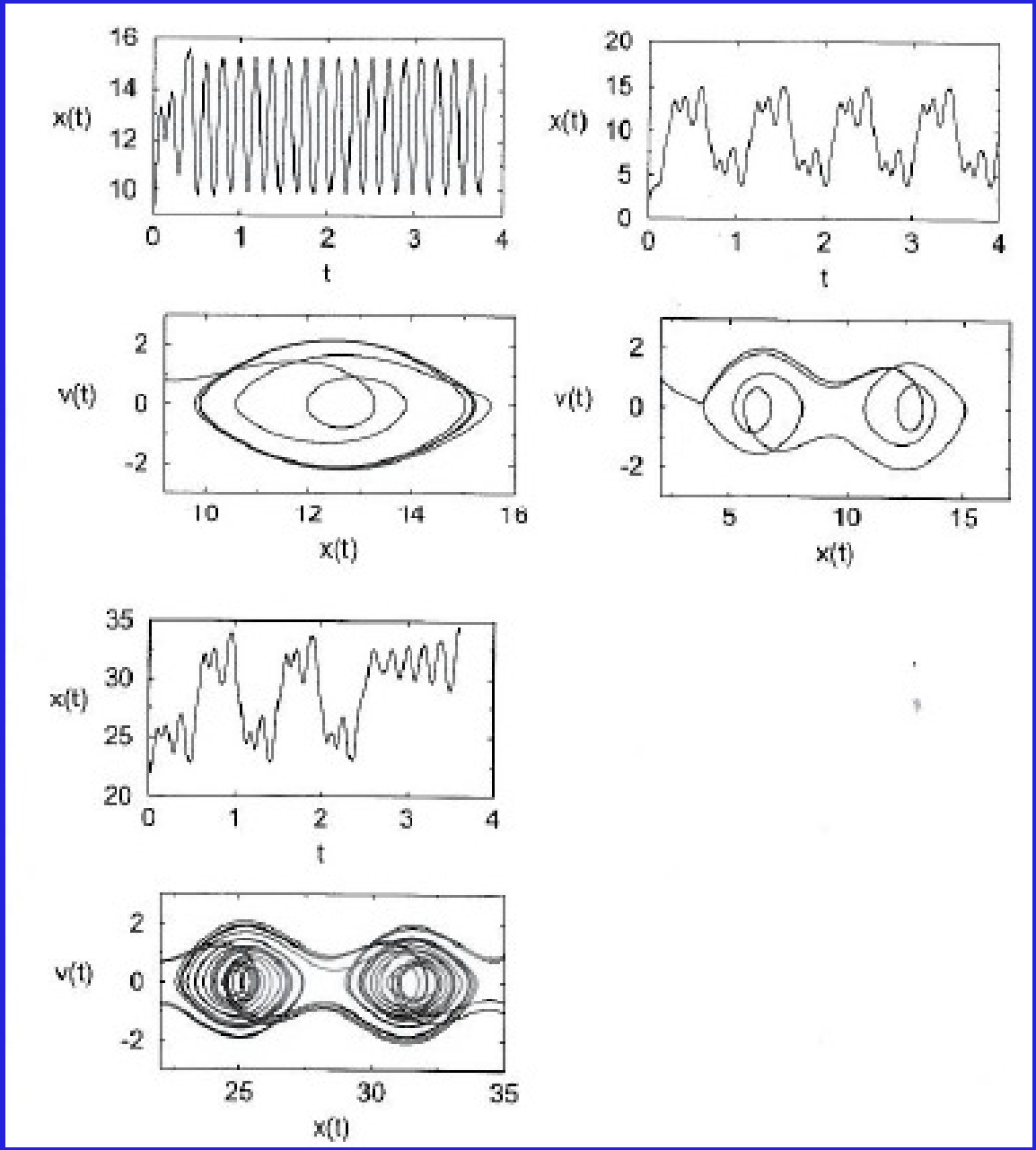
  Choose $\omega_0^2 = 1$ Choose f = 0.52
  Choose $\alpha = 0.2$ Choose $\omega = 0.666$

(x0, v0) = (-0.0885,0.8)

(x0, v0) = (-0.0883,0.8)

(x0, v0) = (-0.0888,0.8)

Chaotic Pendulum (3)



REVIEW: vdpol.cc

Need a way to use more than 1 parameter in an ODE.

Copy vdpol.cc

```
int
    func (double t, const double y[], double f[],
          void *params)
    {

      struct duo{    // this object holds 2 parameters
              double mu;
              double a;
      };

      duo PARAM;
      PARAM = *(duo *)params;
      //       double mu = *(double *)params;
      f[0] = y[1];
      f[1] = -y[0] - PARAM.mu*y[1]*(y[0]*y[0] - pow(PARAM.a, 2.0)); // CHANGE ME
      return GSL_SUCCESS;
```

REVIEW: C++ `struct` data structure

```
// struct construction

#include <iostream>

using namespace std;

int main()
{
  struct triplet{
          double a;
          double b;
          double c;
};

triplet Test;
          Test.a = 10.0;
          Test.b =15.0;
          Test.c = 30.0;
```

Defines variable type “triplet”

Don’t forget semicolon (;) !!

Declares variable Test

Summary

Chaos Intro w/ driven, damped pendulum.

Don’t suffer in silence. Scream for help!!!