

# Math 53 Chaos! Fall 2015: Homework 7

due Thurs Nov 5

Shorter to let you get stuck into projects. (Please do!) This HW covers all remaining material for Midterm 2, ie, up to and including Sec 7.5).

5.2

- A. Compute the Lyapunov exponents of the baker map  $B(x, y) = (x/2, 2y \pmod{1})$  for  $y \geq 1/2$  and  $((1+x)/2, 2y \pmod{1})$  otherwise, acting on the unit square. What does the sum of Lyapunov exponents tell you about what this map does to areas?

T7.2 (ODE review)

7.2 (ODE review.) Also classify as asymptotically stable, stable, or unstable.

T7.9 (ODE review)

T7.5 (quick; sketch the phase plane too)

7.3

7.10 ( $x_2$  for  $b$  is supposed to be a critical point of  $P$ , eg of cubic type)

T7.11 (use the  $P(\mathbf{x})$  for the undriven Duffing oscillator) Please also carefully sketch level curves of  $E$  for the case  $c = 0$ , and phase plane flow curves for  $c > 0$ . This will help you answer it.

Compu. Expt. 7.3 Forced damped Duffing oscillator. Answer the questions in the book for this experiment. You might want to use Matlab's `ode45` for the formulation as two coupled first-order ODEs. See for instance the end of

<http://math.dartmouth.edu/~m46s09/intro46.m>

Go out to at least 200 time units. Please produce a phase plane plot of the three different orbits and state an IC which leads to each: two period- $6\pi$  orbits, one period- $2\pi$  orbit. Remember to clean up your orbits by not plotting an appropriate amount of early 'settling' time. [Hint: to measure periods you'll need to plot graphs vs  $t$ ; you don't need to hand these in].