testing

Computational Physics Homework 1

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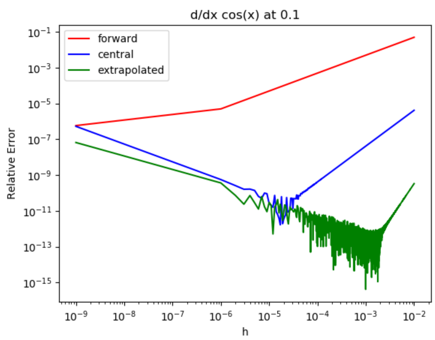
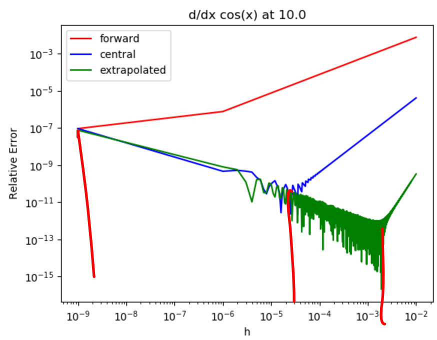
1 Problem 1 - Differentiation

The derivative is well defined for smooth and continuous functions. Finding the derivative of an arbitrary function can involve an analytic or numerical approach. For this problem, we take a numerical approach by three different computational methods. These methods, called the forward, central and extrapolation approaches have been explored here for two functions and a varied parameter space to highlight differences. The parameter space that defined our algorithm's performance were h, how wide the range that we looked for the slope of our tangent line in and x, where the derivative is evaluated. For each of our functions we plot the relative error with respect to the known analytic derivative of the functions.

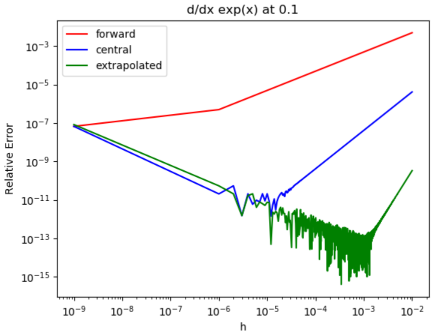


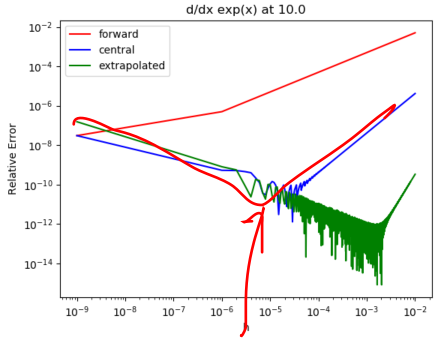


do these agree w/ expectations?

Forward Method:

$$\frac{df}{dx} \simeq \frac{f(x+h) - f(x)}{h} \tag{1}$$





Why two slopes?

Central Method:

$$\frac{df}{dx} \simeq \frac{f(x+h/2) - f(x-h/2)}{h} \tag{2}$$

Extrapolated Method:

$$\frac{df}{dx} \simeq \frac{-f(x+2h) + 8f(x+h) - 8f(x-h) + f(x-2h)}{12h} \tag{3}$$

2 Problem 2 - Integration

Integrating a function over some range can be approached analytically and numerically. Here we explore three different methods for evaluating a definite integral. The parameter space we compare these methods in are N, the number of bins the range is cut up into, and the range itself (a,b). For each method, we compare their relative error with respect to the known analytic definite integral and N.

Midpoint Method:

$$I(a,b) \simeq \sum_{k=1}^{N} f(a + \frac{b-a}{2N} + \frac{k(b-a)}{N}) \tag{4}$$

Trapezoidal Method:

$$I(a,b) \simeq h[\frac{1}{2}f(a) + \frac{1}{2}f(b) + \sum_{k=1}^{N-1} f(a+kh)] \tag{5}$$

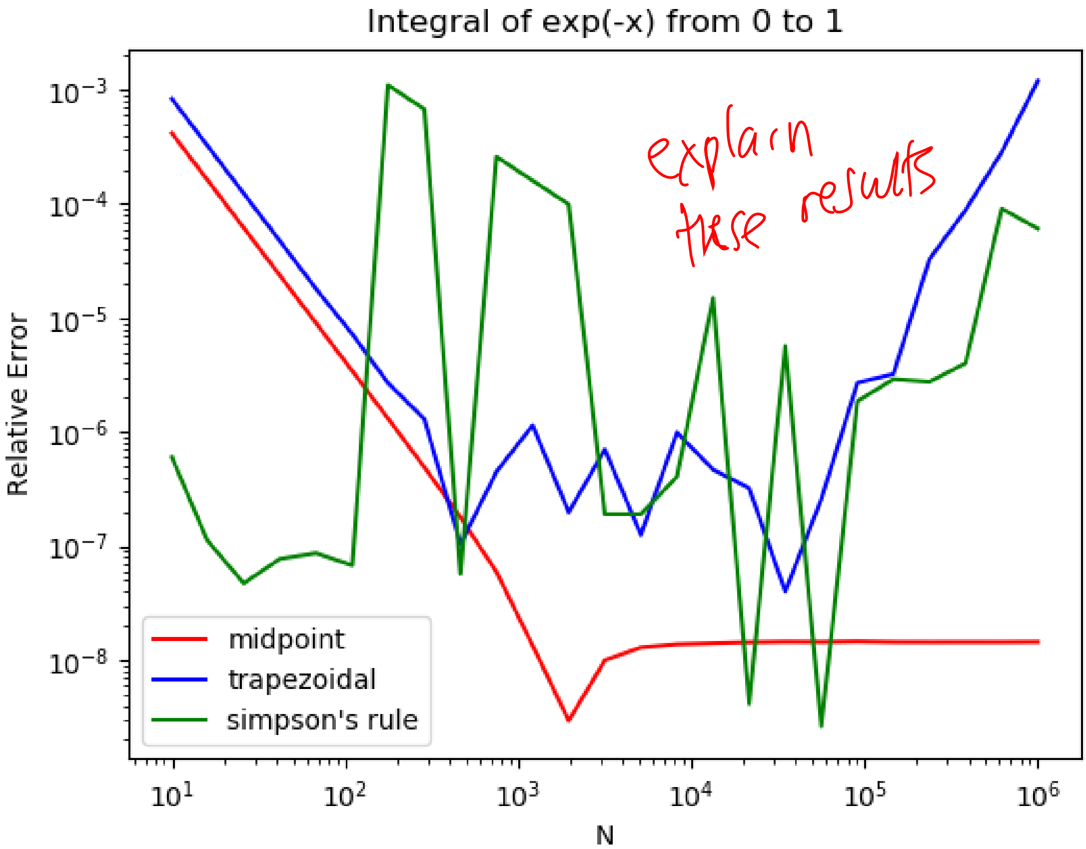


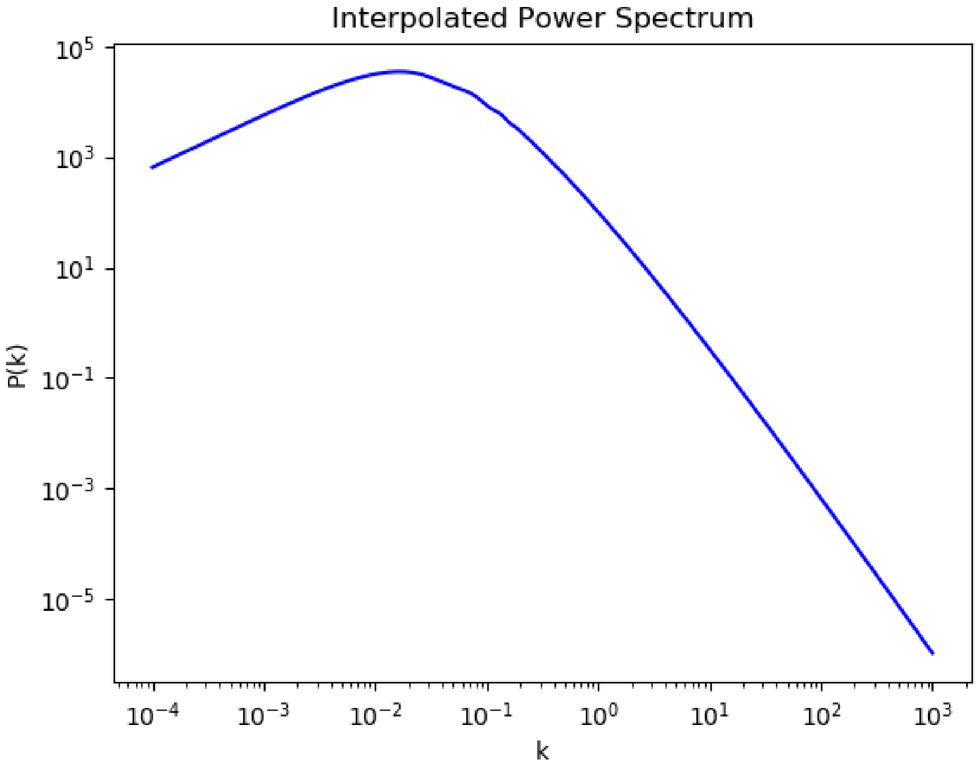
Figure 1: Integration Methods Compared

Simpson's Rule Method:

$$I(a,b) \simeq \frac{h}{3}[f(a) + f(b) + 4\sum_{k=1,odd}^{N-1} f(a+kh) + 2\sum_{k=2,even}^{N-2} f(a+kh)] \tag{6}$$

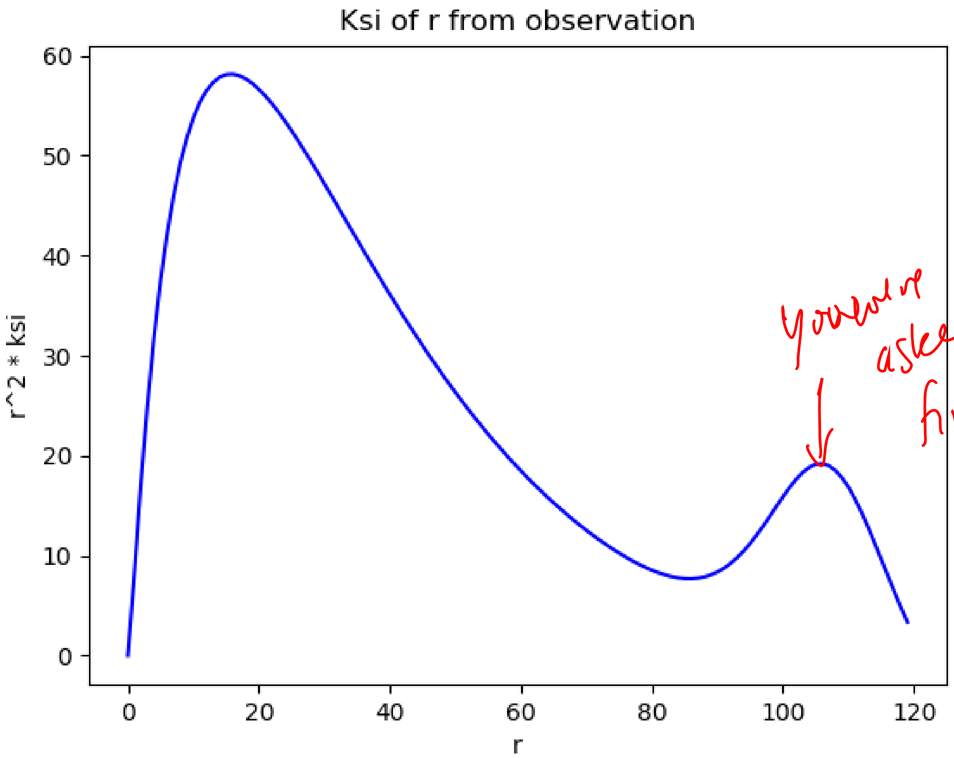
3 Problem 3 - Baryon Acoustic Oscillation

After interpolating a function via the cubic spline method from the provided observational data. We can plot the correlation function over a large range of r and see the effect of the frozen inflationary baryon acoustic oscillations.



Interpolated Power Spectrum
P(k)
10^5
10^3
10^1
10^{-1}
10^{-3}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
k

References



You were asked to find peak.