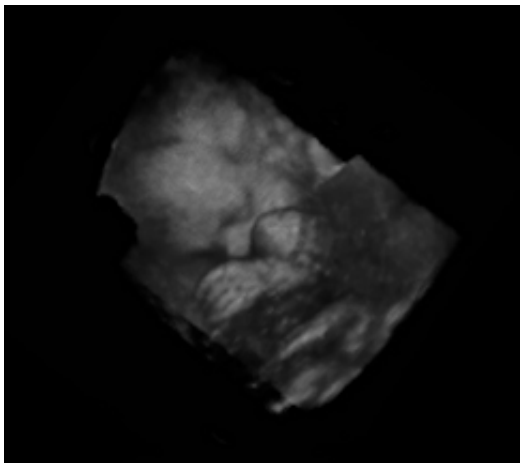
LESSON: Rates of change

FOCUS QUESTION: How can I characterize rates of change?

The rate of change, derivative, or slope measures how quickly a variable changes as a function of the independent variable. Per capita growth rates are useful for comparing values across populations that are changing in size over time.

In this lesson you will:

- Learn about rates of change.
- Use the MATLAB `diff` function.
- Use `end` with colons to pick out elements of an array.
- Calculate the slope.
- Calculate per capita rates of change.



Contents

DATA FOR THIS LESSON

File	Description
	These data sets contain typical fetal size as a function of gestational week: ▪ The first column contains the week ▪ The second column contains the fetal length in cm ▪ The third column contains the fetal weight (mass actually) in grams.

toRump.txt toHeel.txt	The `toRump.txt` data measures length from baby crown to baby rump during early gestation. The `toHeel.txt` measures the length from baby crown to baby heel during later gestation. The data came from http://www.babycenter.com/average-fetal-length-weight-chart.

SETUP FOR LESSON

- Create a `RatesOfChange` directory on your `V:` drive and make it your current directory
- Download the `toRump.txt` and `toHeel.txt` to your `RatesOfChange` directory.
- Create a `RatesOfChangeLesson.m` script file in your `RatesOfChange` directory. Enter each of the examples in a new cell in this script.

EXAMPLE 1: Load the fetal size data

Create a new cell in which you type and execute:

```
load toRump.txt;  % Load the crown-to-rump data
load toHeel.txt;  % Load the crown-to-heel data
```

You should see the following 2 variables in your Workspace browser:

- `toRump` - measures the variation up through week 20
- `toHeel` - measures the variation from week 20 to term

EXERCISE 1: Diagramming an array
Draw a picture of the `toRump` and `toHeel` arrays and label their rows and columns. Explain how these two arrays fit together.

EXAMPLE 2: Merge the time and weight (mass) variables from the two data sets

Create a new cell in which you type and execute:

```
weeks = [toRump(:, 1); toHeel(2:end, 1)]; % Remove first row of second dataset
mass =  [toRump(:, 3); toHeel(2:end, 3)];
weight = mass .* 0.00220462262;           % Convert grams to pounds
```

You should see the following 3 variables in your Workspace browser:

- `weeks` - the gestational week
- `mass` - mass of a typical fetus at that gestational week
- `weight` - the weight of a typical fetus at that gestational week

Verify that these are the first and third columns of the two data sets after they have been put end-to-end without duplicates.

EXAMPLE 3: Calculate the weekly rate of change of fetal weight

Create a new cell in which you type and execute:

```
poundsPerWeek = diff(weight) ./ diff(weeks);       % Weekly rate of change
weekMid = (weeks(1:(end-1)) + weeks(2:end))./2;    % Week midpoints for plotting
```

You should see the following 2 variables in your Workspace browser:

- `poundsPerWeek` - rate of change of weight per week (in lbs/week)
- `weekMid` - a vector of points at the half weeks rather than weeks

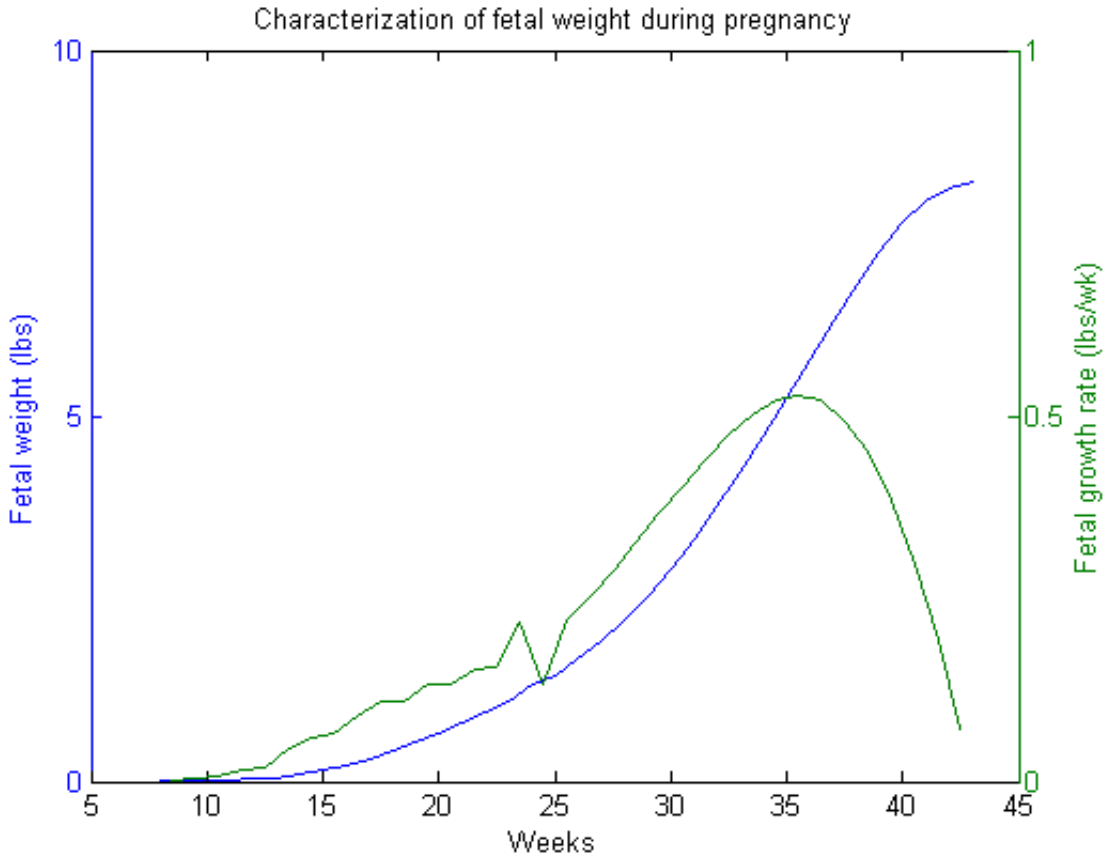
EXERCISE 2: Find the weekly rate of change of mass in kg/week.

EXAMPLE 4: Plot the weight and rate of change of weight

Create a new cell in which you type and execute:

```
figure('Color', [1, 1, 1])                  % New figure
ax = plotyy(weeks, weight, weekMid, poundsPerWeek); % Save axes
xlabel(ax(1), 'Weeks')                      % Label x-axis of left axis
ylabel(ax(1), 'Fetal weight (lbs)')         % Label y-axis of left axis
ylabel(ax(2), 'Fetal growth rate (lbs/wk)') % Label y-axis of right axis
title('Characterization of fetal weight during pregnancy') % Title one of the axes
```

You should see a Figure Window with the following graph:



EXERCISE 3: Display weight as a bar chart rather than a line graph

EXAMPLE 5: Calculate rate of change (slope) of fetal length in inches per week

Create a new cell in which you type and execute:

```
weeksRump = toRump(:, 1);                       % Pick out the weeks
weeksHeel = toHeel(:, 1);
inchesRump = toRump(:, 2).* 0.393800888;        % Convert length to inches
inchesHeel = toHeel(:, 2).*  0.393800888;
inchesPerWeekRump = diff(inchesRump) ./ diff(weeksRump); % Calculate rate of change
inchesPerWeekHeel = diff(inchesHeel) ./ diff(weeksHeel);
```

You should see the following 6 variables in your Workspace Browser:

- `weeksRump` - vector of week numbers in crown-to-rump measurements
- `weeksHeel` - vector of week numbers in crown-to-heel measurements
- `inchesRump` - vector of lengths in crown-to-rump measurements
- `inchesHeel` - vector of lengths in crown-to-heel measurements
- `inchesPerWeekRump` - vector of slopes inches/week in crown-to-rump measurements
- `inchesPerWeekHeel` - vector of slopes inches/week in crown-to-heel measurements

EXERCISE 4: Find the weekly rate of change of fetal length during early gestation (in cm/week).

EXAMPLE 6: Find the midpoints of the weeks intervals for plotting

Create a new cell in which you type and execute:

```
rumpMid = (weeksRump(1:(end-1)) + weeksRump(2:end))./ 2;
heelMid = (weeksHeel(1:(end-1)) + weeksHeel(2:end))./ 2;
```

You should the following two variables in your Workspace Browser:

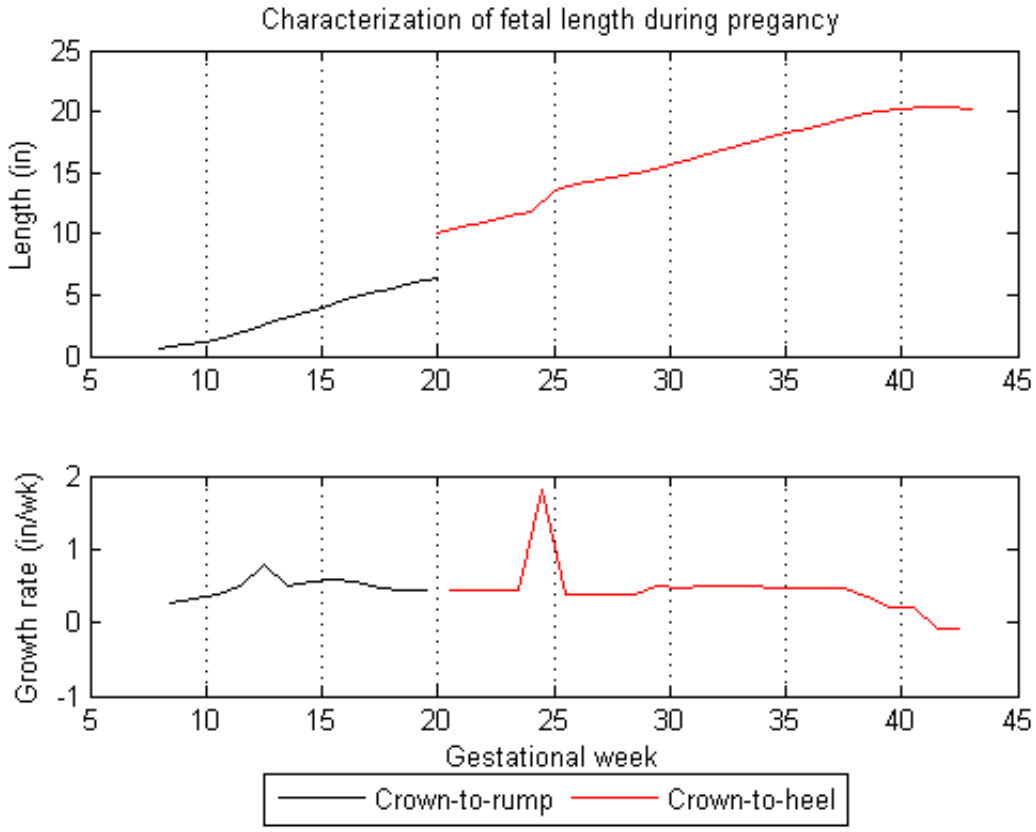
- `rumpMid` - a vector of points at the half weeks for early gestation
- `heelMid` - a vector of points at the half weeks for late gestation

EXAMPLE 7: Plot the weekly rate of change of fetal length in inches/week

Create a new cell in which you type and execute:

```
figure('Color', [1, 1, 1])
subplot(2, 1, 1, 'XGrid', 'on')                % Top panel
hold on
plot(weeksRump, inchesRump, 'k');
plot(weeksHeel, inchesHeel, 'r');
ylabel('Length (in)')
title ('Characterization of fetal length during pregancy')
box on
hold off
subplot(2, 1, 2, 'XGrid', 'on')                 % Bottom panel
hold on
plot(rumpMid, inchesPerWeekRump, 'k');
plot(heelMid, inchesPerWeekHeel, 'r');
xlabel('Gestational week')
ylabel('Growth rate (in/wk)')
box on
legend({'Crown-to-rump', 'Crown-to-heel'}, 'Location', 'SouthOutside', ...
    'Orientation', 'Horizontal')
hold off
```

You should see a new Figure Window with the following plot:



EXAMPLE 8: Calculate the percentage change in fetal weight

Create a new cell in which you type and execute:

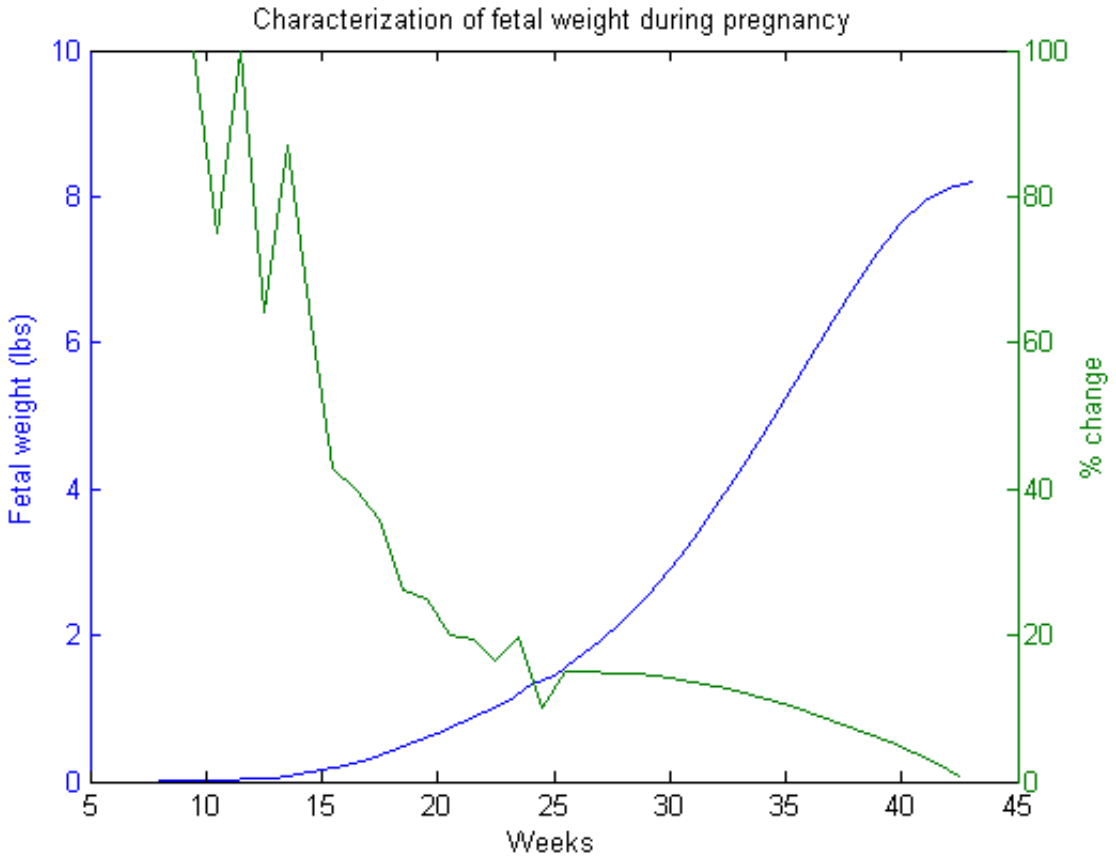
```
percentChangeWeight = 100.*diff(weight)./weight(1:end-1);
```

EXAMPLE 9: Calculate the percentage change in fetal weight

Create a new cell in which you type and execute:

```
figure('Color', [1, 1, 1])                  % New figure
ax = plotyy(weeks, weight, weekMid, percentChangeWeight); % Save axes
xlabel(ax(1), 'Weeks')                      % Label x-axis of left axis
ylabel(ax(1), 'Fetal weight (lbs)')         % Label y-axis of left axis
ylabel(ax(2), '% change') % Label y-axis of right axis
title('Characterization of fetal weight during pregnancy') % Title one of the axes
```

You should see a Figure Window with the following graph:



SUMMARY OF SYNTAX

MATLAB syntax	Description
`end`	designates the last position in a particular dimension when used as an array index.
`y = diff(x)`	returns the difference of adjacent elements along the first non-singleton dimension of `x`.
`ax = plotyy(X1, Y1, X2, Y2)`	creates a graph with two axes, one for `X1` versus `Y1` and the other for `X2` versus `Y2`. The `ax` variable is a two-element vector holding the handles for the respective axes.
`xlabel(ax, 'label')`	labels the x-axis of the axis designated by `ax` with the word `label`. If you omit `ax`, MATLAB labels the current axis.
`ylabel(ax, 'label')`	labels the y-axis of the axis designated by `ax` with the word `label`. If you omit `ax`, MATLAB labels the current axis.

This lesson was written by Kay A. Robbins of the University of Texas at San Antonio and last modified 24 May 2015. Please contact kay.robbins@utsa.edu with comments or suggestions. The image is a sonographic 3D-image of a fetus created by Gebruiker Mvandergaast. The image is available on Wikipedia as .

Published with MATLAB® 8.3