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```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% CODE CHALLENGE 6 - Template Script
%
% The purpose of this challenge is to predict whether or not the
% Boulder
% Reservoir will have to close due to a major leak.
%
% In Coding Challenge 5, you did the following:
% - Part 1:
%   1) Read in the provided data file
%   2) Estimated reservoir volume w/ Trapezoidal and Simpson's 1/3
%   Rules
%   3) Compared the accuracy of the two results
%
% - Part 2:
%   1) Propagated t and h using Euler's Method
%   2) Used plots to observe the effect of different timesteps on the
%       estimation accuracy
%
% In Coding Challenge 6, you will build upon the code that you wrote
% up
% for Coding Challenge 5. Fill in what you can in the below code
% template
% by using the code you completed last week. Once you get to the
% Runge-Kutta approximation, calculate K-values and use the Runge-
% Kutta
% equations to approximate the reservoir height over time.
%
% In the last section of this code, create plots that effectively
% illustrate differences between approximation methods and parameters,
% comparing Runge-Kutta using different time steps and also Runge-
% Kutta vs.
% Euler's Method.
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% NOTE: DO NOT change any variable names already present in the code.
%
% Upload your team's script to Gradescope when complete.
%
```

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```

% NAME YOUR FILE AS Challenge6_Sec{section number}_Group{group
breakout #}.m
% ***Section numbers are 1 or 2***
% EX File Name: Challenge6_Sec1_Group15.m
%
% STUDENT TEAMMATES
% 1) Caleb Bristol
% 2) Andrew Sapuppo
% 3) Austin Monell
% 4) Yosef Kidanai
% 5)
%
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%

```

## Housekeeping

Don't clear variables (i.e. with "clear"); this makes grading difficult.

```

close all; % Close all open figure windows
clc; % Clear the command window

```

## Prerequisites from Coding Challenge 5 %%

```

% Reading in Provided Depth Data %
data = dlmread('depth_data.csv', ',', 1, 0); % Read in depth data
from .csv
x = data(:, 1); % Position along reservoir
[ft]
h = data(:, 2); % Depth of reservoir
[ft]
L = 4836; % Length of reservoir
[ft]

```

## Set-up for Runge Kutta Method %%

Problem Parameters %

```

h0 = 20; % Initial reservoir depth
[ft]
alpha = 1.5e6; % Relating volume change to depth
[ft^2/day]
dV_in = 2e7; % Volume inflow rate
[ft^3/day]

% Approximation Parameters %
timestep = [16 8 4 2 1]; % Timesteps to use for approximation
[days]
for j = 1:length(timestep)
    t_end = 200; % Choose an end time for your program
[days]

```

---

```

    t = 0:timestep(j):t_end; % Allocate a time vector
[days]
    h = zeros(1,length(t)); % Allocate a depth vector
[ft]
    h(1) = h0; % Set a depth vector initial value
[ft]
    h_RK = h; % Set a depth vector for Runge-Kutta
[ft]

    for i = 1:(length(t)-1) % Euler's Method - use your code from Lab
6
        dhdt = get_dhdt(h(i),L,alpha,dV_in); % Get dh/dt at
this depth [ft/day]
        h(i+1) = h(i) + dhdt * timestep(j); % Compute next
depth value
    end

    for i = 1:(length(t)-1) % Runge-Kutta Method
        K1 = get_dhdt(h_RK(i),L,alpha,dV_in); % Calculate
your K1 value
        K2 = get_dhdt(h_RK(i) + K1*(timestep(j)/2),L,alpha,dV_in);
% Calculate your K2 value
        K3 = get_dhdt(h_RK(i) + K2*(timestep(j)/2),L,alpha,dV_in);
% Calculate your K3 value
        K4 = get_dhdt(h_RK(i) + K3*timestep(j),L,alpha,dV_in);
% Calculate your K4 value
        h_RK(i+1) = h_RK(i) + (timestep(j)/6) * (K1 + 2*K2 + 2*K3 +
K4); % Compute your next reservoir height [ft]
    end

    % Don't touch these three lines of code... %
    eval(['t_' num2str(timestep(j)) ' = t;'])
    eval(['h_E_' num2str(timestep(j)) ' = h;'])
    eval(['h_RK_' num2str(timestep(j)) ' = h_RK;'])
end

```

## Plotting Results %%

READ THIS: After the above code runs, the "eval" statements at the end of the loop create three sets of variables. One set holds the time vectors used in the various approximations, named "t\_16" for the 16-day time step, "t\_8" for the 8-day time step, etc. Another set holds the Euler approximation results for the various timesteps, named "h\_E\_16" for the 16-day time step, "h\_E\_8" for the 8-day time step, etc. The last set holds the Tunge-Kutta approximation results for the various timesteps, named "h\_RK\_16", "h\_RK\_8", etc. For simplicity, you may use these vectors in your plotting.

```

fig1 = figure('Units','Normalized','Position',[0 0.25 0.65 0.50]);

% Part 1: Effect of timestep on Euler's Method approximation %
subplot(1,2,1)
hold on
title('Part 1: Effect of Time Step Size on Euler''s Method
Approximation', ...

```

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```

    'Interpreter','latex','FontSize',14)
% Here, plot the results of your Euler's approximation using different
% time steps. Is there a significant difference between time steps?
...
plot(t_16,h_E_16);
plot(t_8,h_E_8);
plot(t_4,h_E_4);
plot(t_2,h_E_2);
plot(t_1,h_E_1);
legend("\DeltaT = 16","\DeltaT = 8","\DeltaT = 4","\DeltaT =
    2","\DeltaT = 1");
hold off
% Part 2: Effect of timestep on Runge-Kutta approximation %
subplot(1,2,2)
hold on
title('Part 2: Effect of Time Step Size on RK Approximation', ...
    'Interpreter','latex','FontSize',14)
% Here, plot the results of your Runge-Kutta Method approximation
% using different
% time steps. Is there a significant difference between time steps?
...
plot(t_16,h_RK_16);
plot(t_8,h_RK_8);
plot(t_4,h_RK_4);
plot(t_2,h_RK_2);
plot(t_1,h_RK_1);
legend("\DeltaT = 16","\DeltaT = 8","\DeltaT = 4","\DeltaT =
    2","\DeltaT = 1");
hold off

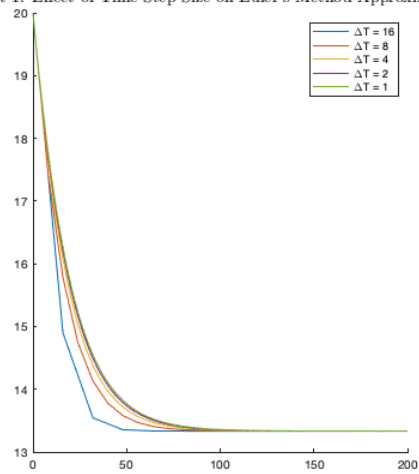
fig2 = figure('Units','Normalized','Position',[0.65 0.25 0.35 0.50]);
hold on

% Part 3: Comparing Runge-Kutta to Euler's Method %
title('Part 3: Comparing RK Approximation to Euler's Method', ...
    'Interpreter','latex','FontSize',14)
% Here plot the results of your Runge-Kutta and Euler's Method
% approximations together. You are encouraged to use a few different
% step
% sizes for Euler's Method, but you can decide for yourself how best
% to
% illustrate the difference in accuracy between Euler and Runge-Kutta.
% Is
% there a significant difference in approximation accuracy?
...
plot(t_16,h_E_16);
plot(t_4,h_E_4);
plot(t_1,h_E_1);
plot(t_16,h_RK_16); %I chose deltaT = 16 for RK because it shows how
% in the least accurate RK is marginally more accurate than Euler's
legend("Euler's \DeltaT = 16","Euler's \DeltaT = 4","Euler's \DeltaT =
    1","Runge-Kutta \DeltaT = 16");
hold off

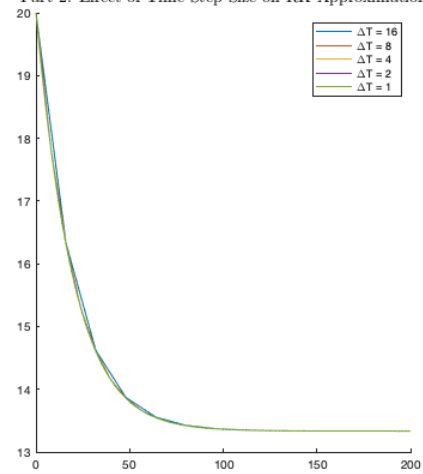
```

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Part 1: Effect of Time Step Size on Euler's Method Approximation



Part 2: Effect of Time Step Size on RK Approximation



Part 3: Comparing RK Approximation to Euler's Method

