Crash Carts

1/29/20

PH 211

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Description:

In this lab we are exploring the concepts of dynamics and kinematics by gathering data to describe the way carts move down the hallway. The goal is to come up with a strategy to move the cart a specific distance with a constant velocity. In doing so, we will also be experiencing parts of Newton's 1st and 2nd laws. As usual, we will be using python tools to plot our data. The goal is to be able to analyze these plots to understand this experiment.

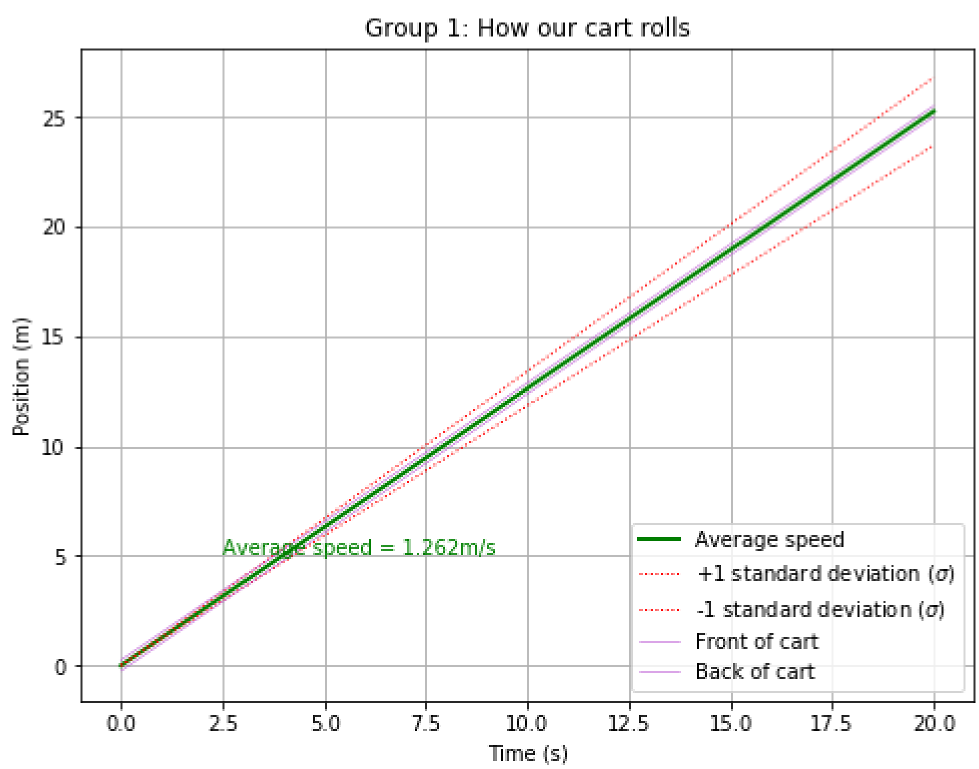
In [2]:
```
#Import python tool libraries needed

import numpy as np
import matplotlib.mlab as mlab
import matplotlib.pyplot as plt
import matplotlib.patches as patch
```

In [3]:
```
#Enter group 1 data (fast group)
#Katherine, Walker, Casey, Nic, Ryan

speeddata = [1.33,1.19,1.24,1.21,1.40,1.20]
speedmean = np.mean(speeddata)
speedsigma = np.std(speeddata)
variability = 100.*speedsigma/speedmean

#Print/check our data entries

print("Group 1: Fast group")
print("Our average speed is %.3f m/s with a standard deviation of %.3f."
% (speedmean,speedsigma))
print("Our variability is %.2f%%" % variability)
```

```
Group 1: Fast group
Our average speed is 1.262 m/s with a standard deviation of 0.077.
Our variability is 6.13%
```

In [4]:
```
#Group 1 actual model parameters - slope and intercept

slope1ave = speedmean
slope1plus = speedmean+speedsigma
slope1minus = speedmean-speedsigma
modelint = 0.
halfwidth = .25 # half the width of the cart


#Group 1 range of t values -- choose lower and upper limits of range
modelx = np.linspace(0.,20.,20.)


#Generate y values from model
model1avey = slope1ave*modelx + modelint


#These are the locations of the front and back of cart
model1fronty = model1avey + halfwidth
model1backy = model1avey - halfwidth


#These are the likely fast and slow models from my variability
model1plusy = slope1plus*modelx + modelint
model1minusy = slope1minus*modelx + modelint
```

In [5]:
```
#Plot Group 1 data

fig2, ax2 = plt.subplots()

ax2.plot(modelx, model1avey, color = 'green', linestyle = '-', linewidth
= 2., label = "Average speed")
ax2.plot(modelx, model1plusy, color = 'red', linestyle = ':', linewidth
= 1., label = "+1 standard deviation ($\sigma$)")
ax2.plot(modelx, model1minusy, color = 'red', linestyle = ':', linewidth
= 1., label = "-1 standard deviation ($\sigma$)")

ax2.plot(modelx, model1fronty, color = 'mediumorchid', linestyle = '-',
linewidth = .5, label = "Front of cart")
ax2.plot(modelx, model1backy, color = 'mediumorchid', linestyle = '-', l
inewidth = .5, label = "Back of cart")

ax2.set(xlabel='Time (s)', ylabel='Position (m)',
       title='Group 1: How our cart rolls')
ax2.grid()
fig2.set_size_inches(8, 6)

plt.text(2.5,5.1, "Average speed = 1.262m/s", color = "green")

plt.legend(loc= 4)

plt.show()
```

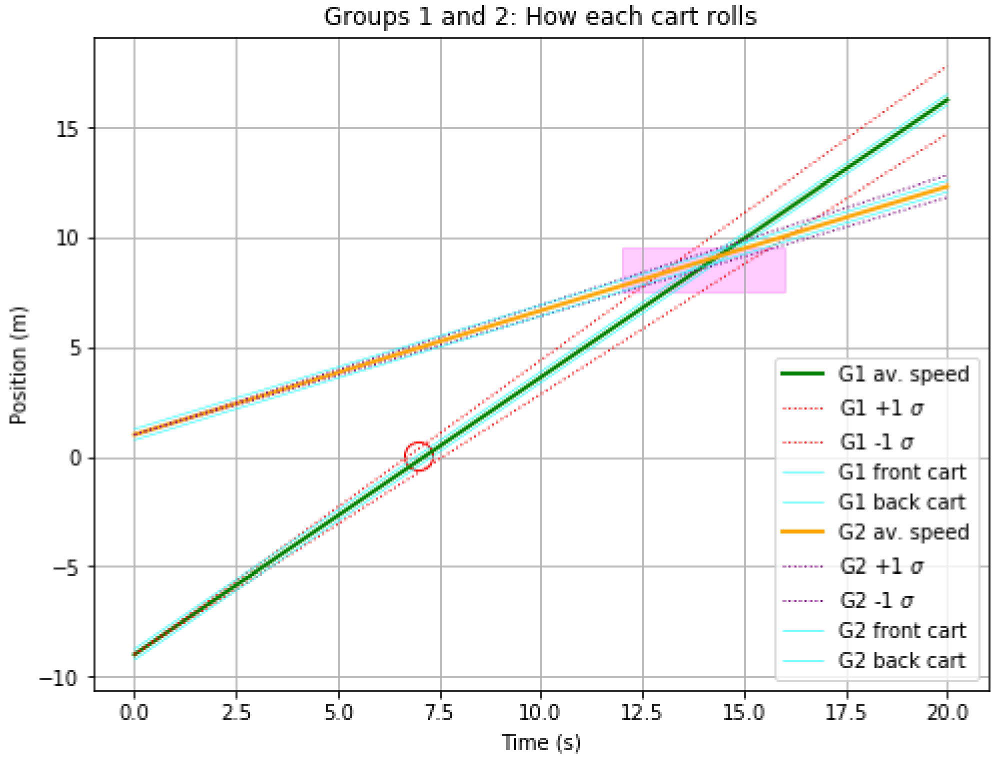


In [6]:
```
#Enter group 2 data (slow group)
#Tyler finch, Alaric hartsock Hannah, Luke

speeddata2 = [.60,.5314,.565,.541,.57,.56,.606,.549]
speedmean2 = np.mean(speeddata2)
speedsigma2 = np.std(speeddata2)
variability2 = 100.*speedsigma2/speedmean2

#Print/check group 2 data entries

print("Group 2: Slow group")
print("Group 2 average speed is %.3f m/s with a standard deviation of %.
3f." % (speedmean2,speedsigma2))
print("Group 2 variability is %.2f%%" % variability2)
```

```
Group 2: Slow group
Group 2 average speed is 0.565 m/s with a standard deviation of 0.025.
Group 2 variability is 4.39%
```

In [7]:
```
#Group 2 actual model parameters - slope and intercept

slope2ave = speedmean2
slope2plus = speedmean2+speedsigma2
slope2minus = speedmean2-speedsigma2
model2int = 1.

#Group 1 regenerate y values from model with potential different interce
pt

modelint = -9.
model1avey = slope1ave*modelx + modelint
model1fronty = model1avey + halfwidth
model1backy = model1avey - halfwidth
model1plusy = slope1plus*modelx + modelint
model1minusy = slope1minus*modelx + modelint


modelx = np.linspace(0.,20.,20.)

#Group 2 generate y values from model

model2avey = slope2ave*modelx + model2int
model2fronty = model2avey + halfwidth
model2backy = model2avey - halfwidth
model2plusy = slope2plus*modelx + model2int
model2minusy = slope2minus*modelx + model2int
```

In [8]:
```
fig3, ax3 = plt.subplots()

# model for cart 1
ax3.plot(modelx, model1avey, color = 'green', linestyle = '-', linewidth
= 2., label = "G1 av. speed")
ax3.plot(modelx, model1plusy, color = 'red', linestyle = ':', linewidth
= 1., label = "G1 +1 $\sigma$")
ax3.plot(modelx, model1minusy, color = 'red', linestyle = ':', linewidth
= 1., label = "G1 -1 $\sigma$")

ax3.plot(modelx, model1fronty, color = 'cyan', linestyle = '-', linewidt
h = .5, label = "G1 front cart")
ax3.plot(modelx, model1backy, color = 'cyan', linestyle = '-', linewidth
= .5, label = "G1 back cart")

# model for cart 2
ax3.plot(modelx, model2avey, color = 'orange', linestyle = '-', linewidt
h = 2., label = "G2 av. speed")
ax3.plot(modelx, model2plusy, color = 'purple', linestyle = ':', linewid
th = 1., label = "G2 +1 $\sigma$")
ax3.plot(modelx, model2minusy, color = 'purple', linestyle = ':', linewi
dth = 1., label = "G2 -1 $\sigma$")

ax3.plot(modelx, model2fronty, color = 'cyan', linestyle = '-', linewidt
h = .5, label = "G2 front cart")
ax3.plot(modelx, model2backy, color = 'cyan', linestyle = '-', linewidth
= .5, label = "G2 back cart")

# start point for delayed cart
ax3.scatter(7., 0, s= 200, marker = 'o', facecolors = 'none', edgecolors
= 'red')

target = patch.Rectangle((12., 7.5), width=4, height=2.,
                             color='magenta',
                             alpha=0.2)

ax3.add_patch(target)

ax3.set(xlabel='Time (s)', ylabel='Position (m)', title='Groups 1 and 2:
How each cart rolls')
ax3.grid()
fig3.set_size_inches(8, 6)
plt.legend(loc= 4)
plt.show()
```



Analysis

Our experimental demonstration was consistent with our model, for the most part. Both carts were a bit delayed when they reached the target, so they ended up being a little over 1m apart. Otherwise, it went as planned.