Kinematics and Full-Downs

New Mexico
Supercomputing Challenge
Final Report
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Team #56
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In cheerleading stunts there are 3 people on the bottom, 2 bases and 1 back-spot, holding up a person on the top, the flyer. The object of cheer stunts, is to get the flyer up on the bases hands, and then to get the flyer down safely. However, sometimes things do not go as planned, like the flyer falling unexpectedly or the bases are not ready to catch. In our program, we take into account that everything goes perfectly up until when the bases catch the flyer.

Our project is centered on motion control in cheerleading stunts. We want to achieve safe landing of the flyer, and prevent injury of the base catching the flyer, and to do this we need mostly physics equations. Our model is controlled by variables specifying the masses of the base and the flyer, various angles of the bases' body parts, the change in time between letting go of the flyer and catching. But, recently, we have discovered that figuring out the successfulness of a cheerleading stunt is impossible to achieve. However, we were already too far into the year to start all over again, so we couldn't have done something else.

Before February, when we thought our project was going to work, we video-taped cheerleading stunts from the Los Alamos High School cheer squad, and looked at what went wrong when stunts failed, and what went right when stunts were successful. We have found out several positive characteristics of stunting in cheerleading, as follows:

- The more strength someone has, the more neutral force they exert on the flyer.

- The angles of the legs, elbows, and armpits contribute to the success or the failure of the stunt.
- If the bases are not very strong, using good angles of arms, legs and elbows will still help them catch the flyer safely.
- Bases must use more muscles in the legs than in the arms.

In the last phase, Stephanie Djidjev was the only one in the team still motivated enough to continue working on bringing the model towards more realistic scenario as advised by the judges we talked to on February 21, 2009. The working mechanics and the energy released in the human muscle tissue are highly complex, and for that reason here, we incorporate it as a simple resistance based equation. Of course, we wouldn't have accurate results for this reason, as there isn't an equation for strength.

Another problem with what we picked to model is that it's very unlikely that you will throw a flyer directly vertical, and the flyer to fall all the way down vertically, thus making it into a trajectory problem.

When the bases catch the flyer, the mass is re-distributed all along the bases' body. Such a distribution is impossible to calculate; it is too physical. Also, the center of mass in everyone's body is different, and each plays a key role in cheerleading stunts. If the center of masses are in relatively in the same position for both bases, you'll get a more balanced stunt. If the center is way off, the stunts will become less balanced. That is why it is unusual to have one really tall base and one small base, even though the tall base could bend down to be the same height as the small base, their centers of mass would still be different, thus throwing off the stunt, possibly.

In a real stunt, there is a back-spot giving the bases a boost by pulling up on the flyer’s ankles, and then catching the flyer under the armpits. In the program, we do not give any variables incorporating the base, even though they are very important in the stunt.

Using these equations we made a very simple program using Python:

- $v_{final} = v_{inital} + (acc \times time)$
- $F_{flyer} = (acc \times mass_{flyer})$
- $F_{bases} = (acc \times mass_{bases})$
- $F_{nbases}=((mass_{bases} \times v_{final}^{2}) \div (length \div 100)) - F_{flyer}$

Our program looks like this:

```
import time, random


mass=float(raw_input("What is the mass of the flyer (to the nearest tenth of a kg)?"))
massb=float(raw_input("What is the combined mass of the bases (to the nearest tenth of a kg)?"))
x=500.0
y=200.0
r=63.5
vely=0.0
acc=-9.8
height=120.0
length=10.0

while True:

    armlength= raw_input("Would you like the arm length of the base to be random? Type 'Yes' or 'No'.")
    if armlength == "Yes":
        armlength=random.uniform(57.0,70.0)
    if armlength == "No":
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```
        armlength= float(raw_input("What is the arm length of the base(to the nearest tenth in cm)?"))

    anglearm = raw_input("Would you like the ending angle of the arm of the base to be random?
Type 'Yes' or 'No'.")
    if anglearm == "No":
        anglearm = float(raw_input("What is the ending angle for the arm of the base(to the nearest
tenth)?"))
    if anglearm == "Yes":
        anglearm= random.uniform(0.0,180.0)

    anglepit = raw_input("Would you like the ending angle of the axilla (armpit) of the base to be
random? Type 'Yes' or 'No'.")
    if anglepit == "No":
        anglepit= float(raw_input ("What is the ending angle for the axilla (armpit) of the base (to the
nearest tenth)?"))
    if anglepit == "Yes":
        anglepit= random.uniform(0.0,180.0)
    angleleg= raw_input ("Would you like the ending angle of the leg of the base to be random? Type
'Yes' or 'No'.")
    if angleleg == "Yes":
        angleleg= random.uniform(0.0,180.0)
    if angleleg == "No":
        angleleg= float(raw_input ("What is the ending angle for the leg of the base (to the nearest
tenth)?"))
    time= raw_input ("Would you like the time of the catch to be random? Type 'Yes' or 'No'.")
    if time == "No":
        time= float(raw_input ("How long was the catch, from the point when the highest point to when
the flyer landed in the bases' arms (to the nearest tenth of a second)?"))
    if time == "Yes":
        time= random.uniform(.05,.3)

    velyf=vely+((acc)*(time))
    Fflyer = acc * mass
    Fbases = acc * massb
    Work = Fflyer*120


    success = "notknown"

    Fnbases=((massb*velyf**2)/(armlength/100))-Fflyer
    if Fflyer >= Fnbases:
            success= "Success"
            print success

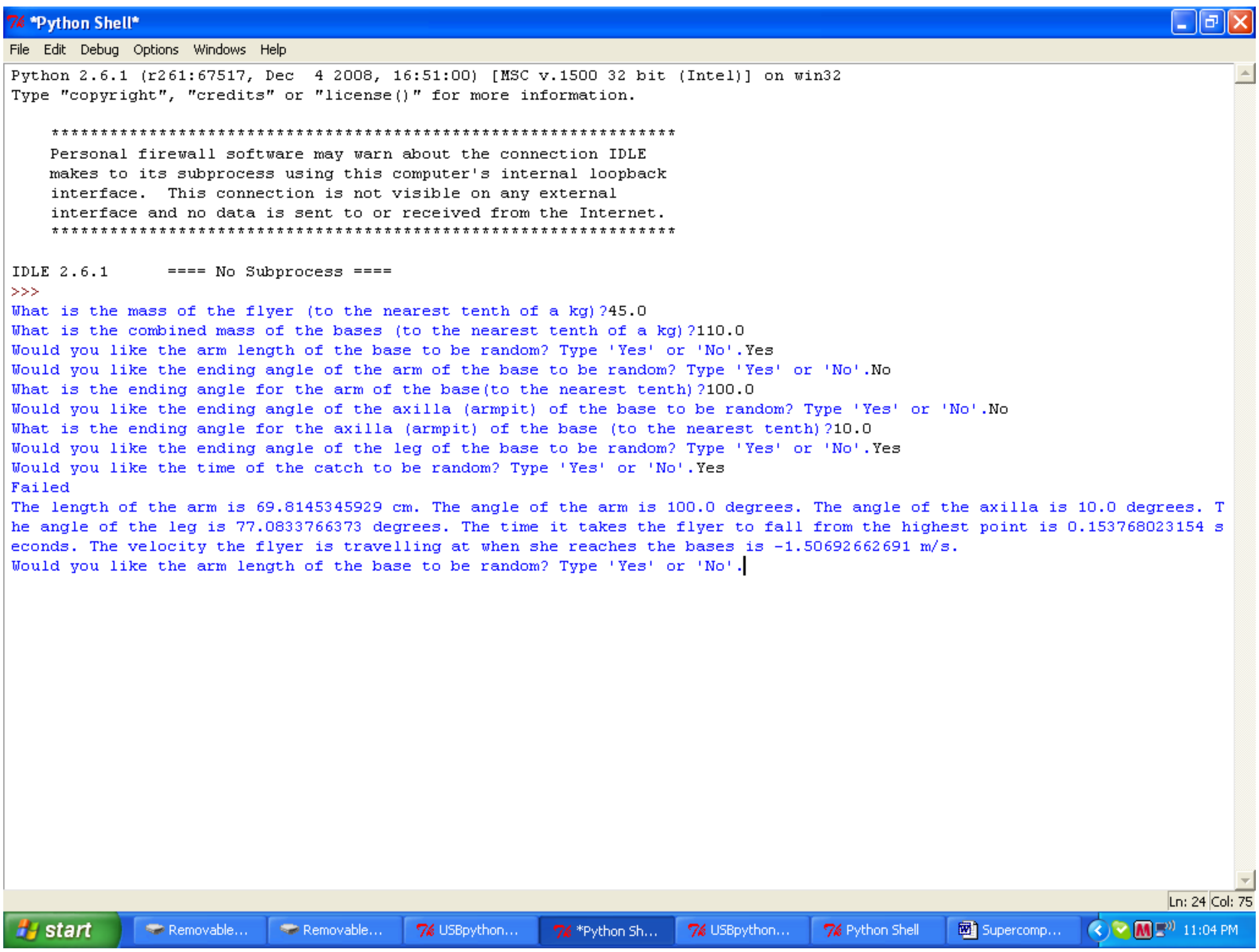
    Workb = Fnbases*120
    if Work >= Workb:
        success= "Success"
        print success


    if 110 <= anglearm <= 140 and 110 <= angleleg <= 140 and 10 <= anglepit <= 40:
        if 240 <= (anglearm + anglepit + angleleg)<= 290:
            success= "Success"
            print success
    else:
        success= "Failed"
```

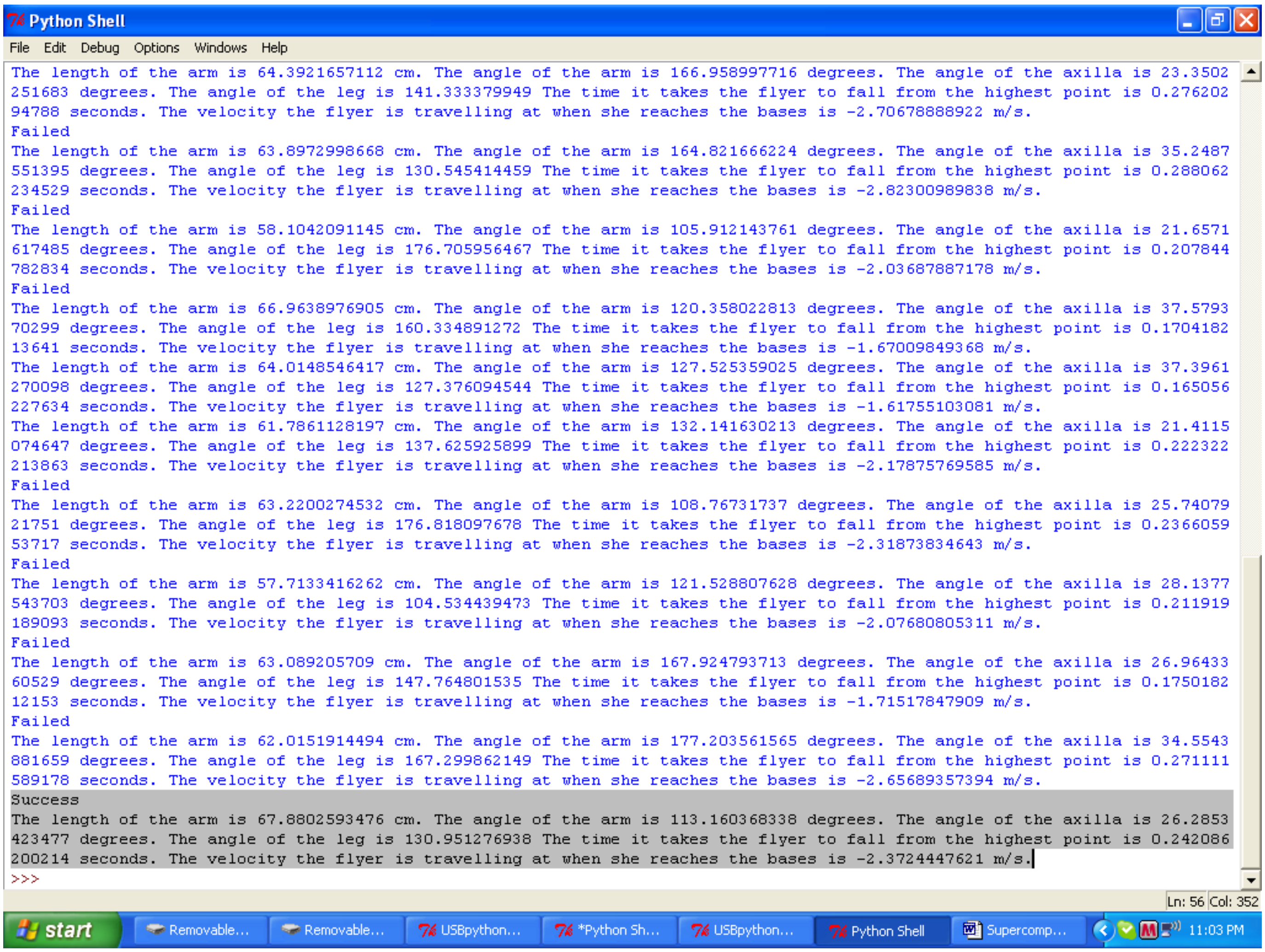
```
        print success
    print "The length of the arm is", armlength, "cm. The angle of the arm is", anglearm, "degrees. The angle of the axilla is", anglepit, "degrees. The angle of the leg is", angleleg, "degrees. The time it takes the flyer to fall from the highest point is", time, "seconds. The velocity the flyer is travelling at when she reaches the bases is", velyf, "m/s."

    if success == "Success":
        True = False
```

With this program, the user can put values for different variables asked. If the user does not want to put a value in, they can make the computer pick a random number within given parameters. Here is a screenshot of the program at work.



If the user just wants to know what good values for each variable are without testing too much, they can use our “while” program that automatically puts all random numbers (within a given parameter) for the variables, and stops when the variables make up a successful stunt.



Resources:

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Cheerleading stunts done by the LAHS Cheer Squad 2009