Board Meeting Alpha:

(a) Unpacking UNCERTAINTY

&

(b) The S.H.O. Dif. Eq.

with respect to

THETA

PHYSICS 204: DANIEL A. MARTENS YAVERBAUM

JOHN JAY COLLEGE OF CRIMINAL JUSTICE, THE CUNY

I. Board Meeting PROCEDURES.

Make certain to read ALL procedures before beginning to follow any of them.

A) Take at least one large white board for each group.

With as much clarity, completeness, color, vivacity and verity as possible,

On group white boards, respond to all the PROBLEMS:

Do not merely solve;
PRESENT, DEPICT & ILLUSTRATE your MENTAL SENSE ("Model")
of the situation and how it unfolds in your mind—

Assume you are explaining and/or defending a point of view.

You may certainly use more than one white board per group.

B) Leave AT LEAST 45 minutes to 1 hour for the following:

Gather in an approximate circle, all Boards facing in.

Discuss the Boards with respect to and for any leading questions posed by the Instructor.

The Instructor, however, will play a noticeably minimal role. Whenever s/he is silent and whenever you wonder what to discuss, do the following:

i. Begin by attempting to identify and reconcile disagreements among boards,

ii. Freely but respectfully follow whatever conceptual/conversation paths emerge from the attempt to reconcile boards.

iii. Emphasize Depth over Breadth:

Once the class discovers that it is disagreement or confusion over a particular and fundamental point--

whether or not this point was originally intended for discussion--

STICK WITH THE CONCEPT PAST THE POINT OF FRUSTRATION & SEEMING 'CIRCLES'.

iv. Do ***not*** interrupt colleagues.

v. Assuming you follow all the foregoing with rigor and respect, do ***not*** submit a lab report.

II. Exemplifying Exercise: UNCERTAINTY

(1) A Europaen Blood Droplet (30 pts).

IN ORDER TO FOCUS ON ***UNCERTAINTY*** IMPLICATIONS,
YOU MUST AT LEAST COMPLETE PARTS

(a) and (h).

It is the year 2034. You are the Chief Medical Examiner…

… in a thriving city on one of Jupiter's moons.

Blood has been spattered from a body, but the body has been removed.

One drop of blood has evidently fallen past the entire length of a smellovision set.

The smellovision set is **2,400.0 cm (+/- .05 cm)*** cm from top to bottom.

A local criminologist has concluded that the drop of blood took **6.00 seconds (+/- .005 seconds)*** to fall past the smellovision set.

The drop of blood had evidently fallen from some unknown height above the top of the smellovision set. Wherever it fell from, it was initially stationary.

On this moon of Jupiter, gravity works exactly the way it does on Earth: It produces a constant acceleration.

The constant acceleration magnitude, however, is NOT 1000 cm/s^2. It is some other unknown number.

… DRAW! DRAW! DRAW! …

a) What was the drop's ***average velocity*** past the smellovision set?

b) Determine the ***time*** at which the drop's ***instantaneous velocity*** was precisely ***400 cm/s***: Was it, for example, ***t=1 sec***? ***t=3.7 sec***? When?

At the ***BOTTOM*** of the smellovision set, a photogate measures the drop's ***instantaneous velocity to be 550*** cm/s.)

c) What is the ***constant acceleration*** due to gravity on this moon of Jupiter?

d) What was the drop's ***instantaneous velocity*** at the top of the smellovision?

e) What was the drop's ***instantaneous acceleration*** as it passed the ***midpoint*** of the smellovision?

f) From how ***high*** above the smellovision did the drop come?

g) Draw a rough but Neat and Clear ***a vs. T*** graph of the drop's motion from t=**0** to t=**4** seconds—the entire time interval for the ***smellovision***.

Use the Y-AXIS for instantaneous ***ACCELERATION*** and use the X-AXIS for TIME (5 pts).

Make sure to LABEL YOUR AXES and LABEL AT LEAST ONE REPRESENTATIVE VALUE ON EACH AXIS.

h) Refer to your answer for the drop's average velocity past the window (part [a]). An expert witness claims that if certain conditions are true, this victim's blood MUST have traveled at an average velocity of 399 cm/sec.
Given the measurement digits and uncertainties provided in the fact pattern, explain why your analyzed velocity IS or IS NOT consistent with this expert witness's prediction. Show all work. NOTE: This is the one and only part of this question where you are actually being asked to perform an analysis of uncertainties.

III. Application and ANALYSIS: Oscillating along an ARC.

Assume a planar, small-angle pendulum of length L.
Assume that the free-fall acceleration due to gravity near Earth's surface is g.

The instructions below should be familiar. You are free

EITHER

To follow them step-by-step ('climb the trees') – and
thereby fully **DERIVE** answers to the boxed research questions

OR

To trust your growing understanding of the larger picture ('consider the forest') and
thereby fully **DERIVE** answers to the boxed research questions

(1) What is the 2nd Order Differential Equation that describes the relationship between

ANGULAR ACCELERATION ($\frac{d^2\theta}{dt^2}$) and
ANGULAR DISPLACEMENT from equilibrium (θ)

for a planar, small-angle pendulum?

(2) Given g and given the Dif. Eq. derived in (a), above,
What is the ***PERIOD*** (T) --
as a function of Length (L)--

for such a pendulum?

... DRAW! DRAW! DRAW! ...

Draw a "Pure" Free-Body-Diagram of the pendulum bob at one arbitrary point in its swing—displaced from the vertical by an angle Theta.

a. Since the pendulum bob swings in the arc of a ***CIRCLE,*** analyze these forces through a coordinate system most convenient for circles: Break up any and all off-axis vectors into components so that every force component lies along either a Radial (Centripetal) Axis, a Tangential Axis or a "Z" Axis ("Z" being perpendicular to the plane of the circle). Draw a "Component" Free-Body Diagram according to this coordinate system.

b. Write down Newton's 2^{nd} Law and apply to each axis separately.

c. Focus on your Newton's Law statement for the axis along which MOTION (VELOCITY) occurs: The tangential axis. Recognize that the acceleration along this axis here is not yet "known", but is, by definition, the second derivative of position with respect to time. Make this substitution in your Newton's Law statement. Note that along this axis, positions advance (change) along the arc length of the circle. Assume that the direction AWAY from the vertical is reckoned POSITIVE. Anything pointing TOWARD the vertical should get a negative sign.

d. Recall the definition of any angle MEASURED IN RADIANS is the ratio of arc length to radius (B2). Using this definition, re-write your Newton's Law statement so that each side of the equality is a function of nothing more than time, the angle theta, the string length and the acceleration due to gravity.

e. Recall that as long as we MEASURE IN RADIANS, the sine of an angle approaches the angle itself as the angle gets closer and closer to 0. Assume that the angles under discussion and observation are extremely small, re-write your Newton's 2^{nd} Law statement as an approximate equality for small angles—one that makes reference only to angles themselves, no trigonometric functions.

f. You now should have a second-order differential equation for which time is the independent variable, angle is the dependent variable and the two constants are length and free-fall acceleration. Clearly write down this differential equation.

g. In at least three three complete sentences of English, explain why this differential equation demands that the pendulum motion SHOULD approximate simple harmonic oscillation under certain conditions. Under what condition will the oscillation start to drift away from simple harmonic?

h. Use your differential equation to derive :

   i. The angular frequency of the pendulum (in terms of ***l*** and ***g***),
   ii. The standard frequency of the pendulum (in terms of ***l*** and ***g),***

The PERIOD of the pendulum (in terms of ***l*** and ***g***).

... DRAW! DRAW! DRAW! ...