AP Physics C
"The Gauntlet II"

Mission Objective: Enter LewWorld undetected, amass as many LewPoints as possible, and escape unscathed and unseen into the darkness until the next secret mission...

Mission Briefing:

1. The Gauntlet will consist of eight tasks, each worth 100 points.
2. The first successful attempt for a task will earn 100 points. If not successful, successive attempts will earn 5 less points than previous attempts (ie. 95, 90, 85, etc.) Each new attempt will have a new set of test values.
3. Each team member must present the following for each task:
   a) a Physics Model (PM),
   b) an Excel Spreadsheet Model (ESM), and
   c) a Physical Demonstration (PD) verifying your model, and
   d) an expert account of the PM, ESM, and PD process and results (i.e. each member should be able to explain process in detail)
   e) Debrief (see questions at end of document)

Rules:

1. Gauntleteers will work in groups of two, following standard double agent protocol.
2. Groups may test their setup as much as they like with random test values.
3. <u>**No testing**</u> shall be down with the "official" test value until the group declares their official test and Mr. Lew is present to view and award LewPoints. Doing so will forfeit your points for the task in question.
4. The winning team members will earn 100 points that will be averaged with their final exam scores. Second place winner will earn 95 points, third place 90, etc. Ties are allowed.
5. Each team member will earn 100 "Lab Points" for each completed task, with no deduction of points if not completed successfully on the first try.

Task 1 – Simple Harmonic Motion I: "Masses on Spring"

Given a spring configuration (single, series, parallel), you will predict the period of oscillation when an unknown mass is placed into oscillation from its equilibrium point.

Known quantities:
Spring configuration (single, series, or parallel)

WARNING! Please show Mr. Lew the estimated "elastic limit" of your spring configuration BEFORE YOU BEGIN TESTING. This limit will be used to determine the maximum stretch of each spring before the spring begins to deform.

Unknown quantity (your test values from Mr. Lew):
Mass M to be placed into oscillation
Amplitude of oscillation

Quantity to determine:
The period of oscillation of the hanging mass

Goal/Tolerance:
The period of oscillation should be within +/- 5% of the predicted value

Task 2 – Simple Harmonic Motion II – “Swingin’ in the rain”

Given a simple pendulum (mass on a string), you will predict the period of the motion and the maximum velocity of the mass during the oscillation.

Known quantities:
The amplitude of oscillation (10° <= angle <= 15°)

Unknown quantity (your test values from Mr. Lew):
The length of the pendulum
The mass on the pendulum

Quantity to determine:
The period of oscillation of mass
The maximum ANGULAR velocity attained by the mass (use rotational motion sensor)
IMPORTANT NOTE: the velocity must be calculated using the following equations (not energy buckets):

SIMPLE HARMONIC MOTION

$$x(t) = x_m \cos(\omega t + \phi) \qquad \omega = \sqrt{\frac{k}{m}} = 2\pi f = \frac{2\pi}{T}$$

MASS ON SPRING

$$T = 2\pi\sqrt{\frac{m}{k}}$$

SIMPLE PENDULUM

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

PHYSICAL PENDULUM

$$T = 2\pi\sqrt{\frac{I}{mgh}}$$

Goal/Tolerance:
The period of oscillation and velocity should be within +/- 5% of their predicted values

Task 3 – Rotational Kinematics – "Atwood's Machine"

Given a set of freely moving masses, m_1 and m_2 on a rotational motion sensor, you will determine the angular acceleration of the system when allowed to freely accelerate.

Known quantities:

The mass of m_1
The "pulley radius" for m_1

Unknown quantity (your test values from Mr. Lew):

The mass of m_2
The "pulley radius" for m_2 (will be different from m_1's)
The angular displacement of the pulley (in radians) that the system will rotate through (this is needed for you to determine the time needed for the system to undergo the given angular displacement)

Quantity to determine:

The angular acceleration α of the system.
The time for the heavier mass (could be m_1 or m_2) to fall a given angular displacement
The time for the pulley to undergo the given angular displacement (e.g. 2π radians or 6π radians)

Goal/Tolerance:

The angular acceleration of the system will be within +/- 10% of the predicted value.
The time needed for the pulley to undergo the given angular displacement will be within +/- 10% of the predicted value.

Task 4 – "Crossbow & Angry Birds©…'nuff said"

Given a crossbow, an angle of inclination, and the horizontal distance from a given Angry Bird©, you will determine the vertical height above the ground your crossbow should be placed so that the dart hits the Angry Bird©.

Known quantities:
Crossbow
Angle of inclination of crossbow (75° <= aiming angle <=15°)
Mass of dart
Color of the Angry Bird© target (i.e. vertical height)

Unknown quantity (your test values from Mr. Lew):
Horizontal distance from Angry Bird© in question.

Quantity to determine:
Vertical height above the ground the crossbow should be placed so that the dart launched from the crossbow hits the Angry Bird© in question.

Goal/Tolerance:
Any part of the Angry Bird© is hit by the dart.

Task 5 – Torque – "Balancing Beam"

Given the mass and location of mass m_1, you will determine the mass of a second mass m_2 to balance the "Balancing Beam of Physics"

Known quantities:
Mass of and location mass m_1
Location of mass m_2

Unknown quantity (your test values from Mr. Lew):
The mass of the second mass, m_2

Quantity to determine:
Mass of mass m_2 that will balance the "Balance Beam of Physics"

Goal/Tolerance:
The centerline of the beam must not move outside of a window +/- 2 cm of its original position when equilibrium is reached

Task 6 – Rotational Inertia - "Heavy Pulleys"

Given a "Heavy Pulley", you will determine the angular acceleration and time for a system of masses m_1 and m_2 to freely unwind on a "heavy pulley"

Known quantities:
The value of mass m_1 and its "pulley radius"

Unknown quantity (your test values from Mr. Lew):
The value of the mass, m_2 and its "pulley radius"
The angular displacement of the pulley (in radians) that the system will rotate through (this is needed for you to determine the time needed for the system to undergo the given angular displacement)

Quantity to determine:
The angular acceleration, α, of the system.
The time for the pulley to undergo the given angular displacement (e.g. 2π radians or $6\ \pi$ radians)

Goal/Tolerance:
The angular acceleration, α, must be within +/- 10% of the predicted value.

Task 7 – Angular Momentum – "Tee Time"

Given a golf club of a known mass, you will determine its angular velocity when released from an unknown height. In addition, you will determine the horizontal location a golf ball travels when hit off of a lab table.

Known quantities:
Mass of golf club
Mass of golf ball

Unknown quantity (your test values from Mr. Lew):
The placement of the pivot point (given as a distance from one side of the golf club)
The release angle θ (given as the angle the golf club make with the vertical)

Quantity to determine:
The angular velocity of the "golf club" the instant before collision with the golf ball
The horizontal distance the ball travels after being hit by the golf club

Goal/Tolerance:
The angular acceleration, α, must be within +/- 10% of the predicted value

Gauntlet Debrief Questions (for each Task)

Each of these questions is to be answered with an explanation or justification. Three to four sentences for each question will suffice.

a. Discuss at least TWO concrete physics concepts that you learned or were clarified for you in this task.
b. Discuss at least ONE physics concept that is still unclear to you after this task. (excluding things such as experimental error…concentrate on physics concepts)
c. What was the difficulty level of the task? (1-10, 10 most difficult) Why?
d. What was the "fun" level of this task? (1-10, 10 most fun). Why?
e. Describe one extension of this task that would help your understanding of the physics content and increase the fun and/or difficulty level of this task.