Lab 2.1: Where a System Balances

Name: _____ **Date:** _____

Grading. Worth **50 points**: 25 for completion, 25 for effort. Effort means readable work, a labeled sketch where one belongs, and a real attempt on every part, not a correct final number. Point values are marked next to each part. Record every reading exactly as the panel gives it, units included, and do not round a measurement to make it agree with a calculation. Follow the assignment etiquette posted on the Assignment Center before you submit.

The simulations are on the lab page, `physicsatsteds.com/ap-physics-c/lab-2-1/`, and you can type your answers straight into it if you would rather not write on paper. Work down the page and use them as you go. Parts 2, 3 and 4 ask you to predict something first, so write the prediction down before you touch the controls. Work symbolically first, write the limits on every integral, and take g = 9.80 m/s^2. Show your work.

1. Warm-up: move the boundary and watch [5 pts]

Two blocks joined by a rope, with a pull on the right one. The three buttons choose what you are calling the system, and the dashed line is the boundary. Nothing here is calculated.

Simulation: "Which blocks are the system."

Move the slider. Press each of the three buttons. Watch which arrows are drawn and which are not. Then write **one sentence** about what you noticed.

2. A rod that is heavier at one end [15 pts]

A rod of length L along the x axis, from 0 to L, with density $\lambda(x) = \lambda_0(1 + kx/L)$. The panel gives both integrals in units that cancel λ_0 and L, so you can compare them with your algebra.

Simulation: "A rod whose density is $\lambda = \lambda_0(1 + kx/L)$."

(a) Set k = 0. Find M and $\int x\,dm$, with limits, and then x_{cm}. Check it against the panel. Now do the same for any k, and write x_{cm} as one fraction in k and L. Check it at k = 3 and at k = 6. **[7 pts]**

(b) What does x_{cm} approach as k grows without limit? Say in a sentence or two why it stops short of L. Then show that x_{cm} is always less than 2L/3. **[8 pts]**

3. Removal is negative mass [15 pts]

A 60 cm square steel plate. Press **Corner bite**, then **Reset**. The bite is then 24 cm by 24 cm, out of one corner.

Simulation: "A 60 cm steel plate with a piece taken out."

(a) Do the general case first. For a plate of side L with a square bite of side s, show that the center of mass moves c = s^2 / [2(L + s)] along each axis. Then put in L = 60 cm and s = 24 cm and compare with the panel. **[7 pts]**

(b) The notch begins L/2 − s from the center. Use that to show the center of mass reaches the empty part when s^2 + Ls − L^2 = 0. Solve for s/L and name the number. Then find the crossing in the simulation and compare. **[8 pts]**

4. What actually follows the parabola [15 pts]

A rod with a ball at each end, thrown across the room. Set the speed to **13.0 m/s**, the angle to **52 degrees** and the spin to **1.2 turns per second**. Leave those three alone and change only the two masses.

Simulation: "A rod with a ball at each end, thrown."

(a) First predict, in writing: if you change the two masses, does the time in the air change? Does the range? Then fill in the table. The length of the rod is never given anywhere; work it out from two rows. Finish with one sentence on what changed and what did not. **[15 pts]**

Left ball (kg)	Right ball (kg)	Balance point from the left ball (m)	Time in the air (s)	Range (m)
3	3			
1	3			
1	9			
9	1			