Rocket Worksheet #3

<u>Prediction Spreadsheet Development</u>

You will be developing a prediction spreadsheet that will allow you to make a prediction of what altitude you think your rocket will reach. This spreadsheet than can be used to make additional predictions for the rockets we use next semester. At the start we will assume the mass of the rocket remains constant during engine burn and while the delay charge is burning.

You will be given a basic spreadsheet made by Mr. Duhrkopf along with an engine data sheet. You will have to enter in information about your rocket and engine in the cells that are highlighted in yellow. These values will be subject to change due to the rocket, engine and weather conditions. The cells highlighted in gray will need formulas to calculate values for various values.

This worksheet should take you through a step-by-step process to develop the spreadsheet. This will be a 3 stage process. We will all use the same mass to start so that we can check that you have the right answers before moving on to the next step. Once completed go back and change the initial mass to the measured mass of your rocket on launch day.

***** Make sure all your answers in N, kg, m, and s*****

1. Open the Beginning Spreadsheet in your Google Docs. Save a copy and name it your rocket name. Invite Mr. Duhrkopf to edit.

2. Find the listed mass of the Estes Guardian rocket and enter this number in B5. (remember SI units!)

3. Find the diameter of the rocket and enter it in B6.

4. Enter a formula in B7 to calculate the cross-sectional area of the rocket. Use PI() for pi. (Lower body tube only!)

5. Using the engine data sheet for the C6-5 engine, enter the initial mass of the engine in E5, the propellant mass in E6, and the after firing mass in E7.

6. Enter a formula in E8 to calculate the delay charge mass in the C6-5 engine.

7. Find the burn time of the C6-5 engine and enter it in E9.

8. Enter 5.00 for the delay time in E10.

9. Enter a formula for the initial total mass of the rocket in B11 and the final total mass in B12.

*****Now that we have entered all the beginning information it is time to start calculating the altitude of the rocket. To do this we will break the flight up into small time intervals during which the acceleration will be constant so we can use the Big Four! The first set of time intervals we will use come from the engine thrust data on the back of the engine specifications worksheet. I have entered the thrust per time period for the C6-5 engine. The first line of the chart will start with the rocket on the launch pad waiting for engine ignition. For this stage we are assuming the mass of the rocket remains constant during engine burn and no drag. *****

10. Using the back of the engine data sheet, double check that the time intervals and thrust values are correct.

11. Enter a formula for the mass of the rocket at t=0 in C15. Use $ to keep value the same if you fill. (C15)

12. Fill this formula down to C39 where the engine has burned out. Remember the mass will remain constant during engine burn. Use $ to keep value the same if you fill down. (C15)

13. List the forces that are acting on your rocket during engine burn and draw a free-body diagram.

14. How would you calculate the net force acting on the rocket at any point in time?

15. How would you calculate the acceleration of the rocket at any point in time?

16. We will assume for the next few steps that drag is 0. Fill down 0 from D15 to D39.

17. The initial velocity and altitude of the rocket is 0. From row 15 to row 16 the engine burns for .031 s with a thrust of .949 N. How would you calculate the acceleration of the rocket? Enter a general formula to calculate the acceleration in E16.

18. Is the acceleration of the rocket negative? If yes, enter 0 for the velocity and altitude in F16 and G16.

19. From .031 s to .092 s the thrust of the rocket is 4.826 N and the initial velocity and altitude of the rocket is 0 from row 16. How would you calculate the acceleration of the rocket during this time period? Enter a general formula to calculate the acceleration in E17. Is this the same formula in E16? Will this always be the formula to calculate acceleration? Fill this formula to E39.

20. How would you calculate the final velocity of the rocket during this time period? Enter a general formula to calculate the final velocity in F17. Remember that the Big Four uses change in time not actual time.

21. How would you calculate the altitude of the rocket after this time period? Enter a general formula to calculate the altitude in G17. Remember that the Big Four uses change in time not actual time.

22. Since the altitude data from Estes is in feet, enter a formula in H16 to convert the altitude in G16 to feet. Fill down to H39.

23. The acceleration of the rocket during the engine burn time periods has been calculated since the formula is always the same. What is the final velocity of the rocket during the .092 s to .139 s time period? Enter a general formula to calculate the final velocity in F18. Is this the same formula in F17? Will this always be the formula to calculate final velocity? Fill this formula to F39.

24. What is the altitude of the rocket after the .092 s to .139 s time period? Enter a general formula to calculate the altitude in G18. Is this the same formula in G17? Will this always be the formula to calculate final velocity? Fill this formula to G39.

25. Check your values and formulas with Mr. Duhrkopf before you proceed.

25. We need to pick time periods to analyze for the rest of the rockets flight time, so in A40 enter =A39+.1 Fill this formula down to A130.

26. Also, since the engine has burned out what is the thrust of the rocket the rest of the flight? Enter this value in B40 and fill down to B130.

27. What will the mass of the rocket be after the engine has burned out? Enter a formula in C40 to calculate the mass. We will assume the mass of the rocket will remain the constant during the time the delay charge is burning which is 5 s. Fill this formula down to 6.86 s. Remember to use $ to keep the cells the same when you fill down.

28. We still will assume the drag is zero. Fill 0 down to D130.

29. Can you find the acceleration of the rocket during the 1.86 s to 1.96 s time period? Is this the same formula that you used during the engine burn phase? Fill down the acceleration formula to 6.86 s row.

30. Calculate the final velocity of the rocket during the 1.86 s to 1.96 s time period. Is this the same formula that you used during the engine burn phase? Fill down the velocity formula to the 6.86 s row.

31. Calculate the altitude of the rocket after the 1.96 s time period. Is this the same formula that you used during the engine burn phase? Fill down the altitude formula to the 6.86 s row.

32. Check your values and formulas with Mr. Duhrkopf before you proceed.

33. At 6.86 s the delay charged is fired. What is the total final mass of the rocket? (See earlier!) Enter this formula in the 6.96 s row and fill down to C130.

34. We still have to find the acceleration, velocity and altitude of the rocket during the rest of the time periods. Since all the formulas are still the same fill down the 4 columns to row 130.

35. In E13 put a formula to calculate the maximum value for the acceleration from E15 to E130.

36. Fill the formula in E13 to the right to H13 to calculate the maximum values for velocity and altitude.

37. What is the maximum altitude for the rocket and when did it occur?

38. Check your values and formulas with Mr. Duhrkopf before you proceed.

Stage 2 - Constant Mass, Drag

1. What factors should we consider when calculating the drag on your rocket?

2. What is the formula for calculating the force due to drag on a rocket?

3. Enter a general formula for finding drag in D16. Make sure and use $ for values that will remain constant.

4. Check your formula and values with Mr. Duhrkopf before proceeding.

5. Fill down the drag formula to D130.

6. What is the maximum altitude for the rocket and when did it occur?

Stage 3 - Changing Mass, Drag

Now we will take into account the change in mass of the rocket throughout the flight. We will assume that the propellant and delay charge will burn at a constant rate. The next few questions will help you develop a formula for finding the propellant and delay charge burn rates. *****Make sure burn time is 1.86 s.******

1. What is the propellant mass of the engine? What cell contains this number?

2. How long does the propellant burn? What cell contains this number?

3. If you divide the propellant mass by its burn time you will have the amount of propellant that burns every second (burn rate). In C16 enter a general formula that would give you the mass of the engine after the propellant burns for the first time period (A16-A15). Remember to calculate the amount of propellant burned during the time period and subtract that from the previous mass in C15. Make sure to use $!!

4. If your value in C16 is .10812 fill down to row 39 at 1.86s. The mass at this row should be .0975.

5. After the propellant finishes burning, the delay charge will burn. What is the mass of the delay charge? What cell contains this number?

6. How long does the delay charge burn? What cell contains that number?

7. Using the same process that you did in #3, enter a formula in C40 that will calculate the mass of the rocket as the delay charge is burning. Remember to calculate the delay charge burn rate and multiply that number by the time period and subtract it from the previous mass in C39.

8. If your value in C40 is .097424 fill down to 6.86 s which is in C89. The mass in this row should be .0937.

9. The rockets mass will not change for the rest of the flight. Enter a cell reference in C90 for the mass and fill down to C130.

    What is the new maximum altitude of your rocket? _________

    When did this maximum altitude occur? _________

9. To get the prediction for your rocket go back and change the mass of the rocket in B5 to your actual measured mass. What altitude did you predict? How does that compare to your actual?

    What is the new maximum altitude of your rocket? _________

    When did this maximum altitude occur? _________

You have now created a prediction spreadsheet for your rocket!!!!!!!!