Quadratic Functions – Vertical Motion

October Sky

1. News Radio Bulletin: “Washington has confirmed that yesterday, ____________, the Soviet Union successfully launched history’s first man-made satellite into space orbit around the Earth.”

2. Homer’s dad’s profession: ______________

3. The name of that 1st Russian satellite: ______________

4. October Sky is based on the true story of _____________ Hickam. How old was he in the movie? __________

5. About how many rockets blew up before they had a successful launch? ______

6. What was the name of the book that Ms. Riley gave Homer for his birthday? ________________________________________

7. Why were the boys arrested? __________________________________________________________________________

8. Why did Homer drop out of school? __________________________________________________________________________

9. What is the name of Ms. Riley’s disease? ______________

10. About how long was the missing rocket’s fall time? ____________

11. About how far away from the launch pad did Quentin calculate the rocket landed? ____________

12. Why was the rocket not exactly where they calculated it would be? __________________________________________________________________________

13. Why can’t Mr. Bolden go to the machine shop to recreate the stolen parts? __________________________________________________________________________

14. Who wins first place at the National Science Fair? __________________________________________________________________________

15. What is the name of the last rocket? ______________

16. How many of the Rocket Boys graduated from college and why was this significant? __________________________________________________________________________

17. When the Rocket Boys grew up, what were their professions?
   a. Quentin ____________________________________________
   b. Roy Lee ____________________________________________
   c. O’Dell ____________________________________________
   d. Homer Hickam ________________________________________
18. When explaining why his rocket did not set the fire, Homer used the formula $S = \frac{1}{2}at^2$.

a. What do the letters $S$, $a$, and $t$ stand for in this equation?

\[
S = \text{__________________________} \\
a = \text{__________________________} \\
t = \text{__________________________}
\]

b. This equation could also be written as $d = 16t^2$, where $d$ is the distance, in feet, that an object falls due to gravity as a function of time, $t$, in seconds. Why is $\frac{1}{2}a$ replaced by 16.

c. Homer states that his rocket fell for 14 seconds and estimates that the rocket’s altitude was 3000 feet. Using $d = 16t^2$, find the actual distance, in feet, that the rocket fell during that time.

d. Using Homer’s estimated altitude of 3000 feet, express the height of the falling rocket as a function of time since it began falling. Sketch the graph of this new function. Label the x- and y-axes on the graph.

\[
h = -16t^2 + vt + s
\]

Vertical Motion Formulas

<table>
<thead>
<tr>
<th>Metric</th>
<th>Customary</th>
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<tbody>
<tr>
<td>$h = -4.9t^2 + vt + s$</td>
<td>$h = -16t^2 + vt + s$</td>
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19. According to the National Association of Rocketry, the current model rocket altitude record in the “F Altitude” event for ages 14 – 18 division is 1430 meters. From this record setting height, the rocket is motionless as it begins its free-fall descent (initial velocity is _____) back to the ground. How long will it take the rocket to hit the ground after reaching its high point? Round to the nearest tenth of a second.

\[
h = \text{______________} \quad \text{Formula: } h = \text{______________}
\]

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20. You arrive at a model rocket competition only to discover that you left your small solid fuel engines at home. In a fit of anger, you throw the engine-less rocket into the air. The rocket leaves your hand 6 feet above the ground with an initial velocity of 45 feet per second. Realizing that you will need the rocket for other competitions, you catch the rocket when it falls back to a height of 5 feet. How long was the rocket in the air?

Formula: \( h = \frac{-16t^2 + vt + s}{g} \)

Graph the flight of the rocket. Include the starting, ending, and maximum points in your table and graph. Label the x- and y-axes.

21. Edwards Air Force Base in California is the touchdown site for the Space Shuttle. The concrete runway is 15,000 feet long! After touchdown, the shuttle will travel a distance, \( d \), given by the equation

\[ d = \frac{v}{r} \cdot t \]

\( v \) is the shuttle's velocity, \( r \) is the shuttle's deceleration rate, and \( t \) is the amount of time that passes before the pilot applies the brakes.

If the shuttle's deceleration rate is -15 ft/sec\(^2\) and the pilot's reaction time is 0.4 seconds, what is the maximum velocity at which the shuttle can land at one end of the concrete runway without overshooting the other end?

Formula: \( d = \frac{v}{r} \cdot t \)

Graph the flight of the rocket. Include the starting, ending, and maximum points in your table and graph. Label the x- and y-axes.
22. You arrive at another model rocket competition and you have remembered to bring your small solid fuel engines. Your rocket is launched from rest and the solid fuel engine delivers a constant acceleration of 8.2 m/sec² for 5 seconds after which the fuel is used up.

a. Using Homer’s formula, \( h = -4.9t^2 + vt + s \), find the altitude of the rocket when the engine shuts down. (Hint: this will be the starting height for part c.)

b. Using the formula, \( v = at \), find the velocity (meters per second) when the engine shuts down. (Hint: this will be the initial velocity for part c.)

c. Find the amount of time the rocket will remain in the air after the engine shuts down.

\[
\begin{align*}
h &= \text{___________} & \text{Formula: } h &= \text{___________________} \\
t &= \text{___________} \\
v &= \text{___________} \\
s &= \text{___________}
\end{align*}
\]

Quadratic Formula Work: Solve for \( t \) to the nearest tenth of a second.

d. Find the TOTAL time the rocket is in the air, including the engine burn.

e. Find the maximum altitude of this flight. (Use your knowledge of parabolas. Where will you find the maximum value on a parabola?)