Stomp Rocket and Newton's Laws Worksheet

1. **Newton's First Law:** Explain how Newton's First Law applies to the motion of a stomp rocket before and after it is launched. Provide one example of inertia in this context.

2. **Newton's Second Law:** A stomp rocket of mass 0.5 kg is launched with a force of 20 N. Calculate its acceleration. Show all your work using the formula $F = ma$.

3. If the mass of the stomp rocket is doubled but the force remains the same, how does the acceleration change? Explain your reasoning.

4. **Newton's Third Law:** Describe the action-reaction forces during the stomp phase of the launch. Identify the action force and the reaction force.

5. **Energy Transformation:** Explain how potential energy is converted into kinetic energy during the launch of a stomp rocket.

6. A student presses down on the stomp pad with a force of 30 N. If the pad compresses by 0.2 m, calculate the work done on the stomp pad. Use the formula $W = F \cdot d$.

7. **Trajectories:** A stomp rocket is launched at an angle of 45 with an initial velocity of 10 m/s. Ignoring air resistance, calculate the maximum height reached by the rocket. Use $v^2 = u^2 + 2as$ (where $a = -9.8\,m/s^2$).

8. How does increasing the launch angle to 60 affect the horizontal distance covered by the rocket? Assume all other factors remain constant.

9. **Real-World Applications:** Discuss how understanding Newton's Laws helps in designing rockets for space exploration. Provide one specific example.

10. **Bonus Question:** How would the rocket's motion change if launched in an environment without air resistance? Explain using Newton's Laws.

Solutions

1. **Newton's First Law:** Newton's First Law states that an object at rest stays at rest, and an object in motion stays in motion unless acted upon by an external force. Before launch, the rocket remains stationary due to inertia. After launch, it continues moving upward until gravity and air resistance slow it down.

2. Using $F = ma$:

$$a = \frac{F}{m} = \frac{20\,N}{0.5\,kg} = 40\,m/s^2$$

The rocket accelerates at $40\,m/s^2$.

3. If the mass is doubled ($m = 1\,kg$), $a = \frac{F}{m} = \frac{20}{1} = 20\,m/s^2$. The acceleration is halved.

4. During the stomp phase, the action force is the foot pushing on the stomp pad, and the reaction force is the stomp pad pushing back on the foot with equal magnitude.

5. Potential energy stored in the compressed stomp pad is converted to kinetic energy, propelling the rocket upward.

6. Using $W = F \cdot d$:

$$W = 30\,N \cdot 0.2\,m = 6\,J$$

7. Using $v^2 = u^2 + 2as$:

$$0 = (10\,m/s)^2 + 2(-9.8\,m/s^2)(s)$$

Solving for s:

$$s = \frac{-100}{2 \cdot -9.8} = 5.1\,m$$

8. Increasing the launch angle to 60 increases the vertical component of velocity, reducing the horizontal distance.

9. Understanding Newton's Laws allows engineers to optimize thrust and minimize mass in rocket design. For example, NASA's Saturn V rocket used precise calculations of $F = ma$ for its stages.

10. In an environment without air resistance, the rocket's motion would follow a perfect parabolic trajectory, and its range would be maximized.