2016 Cypress Falls Invitational

Hovercraft

Team Number: ______ School: _________________________
Names: ____________________________

Score: ______/80

Instructions:
- You will have 42 minutes to complete this test. We will be calling teams up to test their hovercrafts for 8 minute intervals; you will get the rest of the 50 minutes to complete the written test. If you finish build testing before your 8 minutes is up, you can return to this test.
- Circle or box your final answers!
- Please use correct significant figures and units where applicable.
- Show all work.
- Point values are listed after questions
- Good luck!
Newton’s Laws of Motion (12 points)
1. The Tsiolkovsky rocket equation can be derived from what equation? (1)

2. If I push a box weighing 7 kilograms across the floor with an acceleration of .04 m/ s², and the coefficient of kinetic friction between the box and floor is .38, what force am I applying to the box? (2)

3. Consider two people standing on a frictionless surface. Person A pushes Person B, and they both begin to move in opposite directions, but at different speeds. Explain how this is possible, considering that Newton’s 3rd law states that every action has an equal and opposite reaction. (3)

4. When and in what text were these laws first compiled? (1)

5. Explain how each of Newton’s laws affects a game of Tug of War (3)

6. The following graph shows frictional force plotted against applied force. Label where the coefficient of static friction is relevant, and where the coefficient of kinetic friction is relevant. (2)
Kinematics (22)
7. For $0 \leq t \leq 6$, a particle is moving along the x-axis. The particle’s position, $x(t)$, is not explicitly given. The velocity of the particle is given by $v(t) = 3\cos(e^{t/3}) + 6$. Is the speed of the particle increasing or decreasing at time $t = 5.5$? Give a reason for your answer. (3)

8. A projectile is launched from the ground at a velocity of 39 m/s and an angle of 21 degrees.
a. At what time after the launch will the projectile reach the highest point in its trajectory? (2)

b. What will its velocity be at that point? (2)

c. What is the range of this projectile? (2)

9. Velocity is a change in position per unit time. Acceleration is a change in velocity per unit time.
a. What is the term for a change in acceleration per unit time? (1)

b. The following graph shows how a particle moves over time by graphing its position. What aspect or quality of the graph represents the particle’s acceleration at some given time? (1)
10. A football is kicked with an initial velocity of 15 m/s at an angle of 30 degrees with the horizontal.

c. How long is the football in the air? (2)

d. What is the horizontal displacement of the football? (2)

e. What is the peak height of the football? (2)

11. An object is thrown straight upward with an initial speed of 8 m/s and strikes the ground 3 seconds later. What height was the object thrown from? What is its acceleration? (4)

12. Derive an equation that expresses the final velocity of an object in terms of its initial velocity, acceleration, and distance from origin. (1)

Kinetic Energy (15)

13. Block A of mass m is moving at velocity +v towards mass B of mass 2m which is at rest. To its right and at rest is mass C of mass m. Find the ultimate velocities of all three masses assuming all collisions are elastic. Answers should be in terms of v. (4)
14. Below is an image of a U shaped water slide. People in inner tubes are dropped down one side of the U, and then slide back and forth. If the velocity of a child and inner tube with combined mass 34 kg is 32 m/s at the lowest point of the slide, what is the greatest height they will slide, assuming that no energy is dissipated? (2)

15. A basketball (0.62 kg, 24 cm radius) is dropped from the empire state building. The ball’s final linear velocity was 50 m/s and its final angular velocity was 23 rad/s. How much energy did the ball have upon impact? Assume the ball is a hollow sphere. (2)

16. A lump of ice falls from the tip of a mountain. If the ice hits the ground with a vertical speed of 85 m/s what was the height of the mountain the ice fell off of? (Assume friction is negligible) (2)
17. The kinetic energy of a boat is calculated to be 52,000 J. If the boat had a mass of 39,000 kg, with what velocity is it moving? (2)

18. Given that an object starts from rest and is accelerated by a constant force, derive the formula for its kinetic energy expressed in terms of its mass and velocity, starting with \( W = Fd \). (3)

Air Cushioned Vehicles and Applications (15)
19. What does SES stand for, and what two advantages does it have over a hovercraft for sea operation? (3)

20. Identify the parts of this ACV (4)
   1. ____________________________
   2. ____________________________
   3. ____________________________
   4. ____________________________

21. What three things did Sir Christopher Cockerell’s group accomplish before anyone else? (3)
22. What plan did Jean Bertin advocate for in response to the problem of air loss caused by the high skirt design? (2)

23. Small crafts are generally powered by how many engines? Additional engines provide what for the hovercraft? (2)

24. What was the first hovercraft used for military purposes? (1)

Fluid Mechanics (16)
25. A rock, which weighs 1370 N in air, has an apparent weight of 830 when submerged in fresh water (998 kg/m3). The volume of the rock is... (2)

26. The following questions are about types of flow.
   a. Identify the following diagrams as laminar or turbulent flow. (2)
   A. 
   B. 

   b. The Reynolds number of the ratio of what to what? (2)

   c. Does laminar flow have a lower or higher Reynolds number than turbulent flow? (1)
27. Why is the Navier-Stokes equation more applicable than the Euler equations when describing fluid dynamics? (2)

28. What is the difference between Newtonian fluids and Non-Newtonian fluids? Provide two examples of Non-Newtonian fluids? (3)

29. What is the tension in the string in this figure? The volume of the plastic ball is 95 cm³ and the density is 840 kg/m³. (2)

30. A rectangular boat made out of concrete with a mass of 1200 kg floats on a freshwater lake (ρ=1000 kg/m³). If the bottom area of the boat is 6 m², how much of the boat is submerged? (2)