Unit 2 Practice Quiz: Systems, Forces and Gravitation

Name: ______________________________ **Date:** ______________

Equations. $\vec{r}_{cm} = \dfrac{\sum m_i \vec{r}_i}{\sum m_i} = \dfrac{1}{M}\int \vec{r}\,dm \quad M = \int dm \quad dm = \lambda\,dx \quad \sum \vec{F}_{ext} = M\vec{a}_{cm} \quad \sum \vec{F} = m\vec{a} \quad \vec{F}_g = m\vec{a}_g \quad F_g = G\dfrac{m_1 m_2}{r^2}$
$g = \dfrac{GM}{r^2} \quad \vec{F}_{AB} = -\vec{F}_{BA}$

Given. $\vec{a}_g = -9.80665\,\hat{\jmath}$ m/s^2 $\quad G = 6.67 \times 10^{-11}$ N·m^2/kg^2 Every surface is frictionless unless a question says otherwise.

Part A. Multiple choice. All eight required. Circle one letter for each. 3 points each, 24 points total. About 14 minutes.

1. A rod of length L has linear mass density $\lambda(x) = \lambda_0\left(2 - \dfrac{x}{L}\right)$ for $0 \le x \le L$. Its center of mass lies **[3 pts]**

(A) exactly at $\dfrac{L}{2}$.
(B) between 0 and $\dfrac{L}{2}$.
(C) between $\dfrac{L}{2}$ and L.
(D) outside the rod.

2. For a nonuniform solid, the total mass is found by integrating the density over the body rather than multiplying density by size, because **[3 pts]**

(A) the density is different at different points, so no single value can be multiplied.
(B) integration is more accurate than multiplication.
(C) the center of mass is not at the middle.
(D) the units do not work out otherwise.

3. A ball is thrown straight up. At the instant it reaches its highest point, the forces on it are **[3 pts]**

(A) none, since it is momentarily at rest.
(B) the gravitational force only.
(C) the gravitational force and an upward force that is about to run out.
(D) an upward force equal to the gravitational force.

4. A book rests on a table. The third law partner of the gravitational force the Earth exerts on the book is **[3 pts]**

(A) the normal force the table exerts on the book.
(B) the gravitational force the book exerts on the Earth.
(C) the force the book exerts on the table.
(D) the weight of the table.

5. In an Atwood machine two unequal masses hang from an ideal string over an ideal pulley and are released. The acceleration of the center of mass of the two blocks is **[3 pts]**

(A) zero, because the two accelerations are equal and opposite.
(B) downward, and smaller in magnitude than the acceleration of either block.
(C) downward, and equal in magnitude to the acceleration of either block.
(D) upward, toward the lighter block.

6. The net force on an object is doubled and its mass is doubled at the same time. Its acceleration **[3 pts]**

(A) is unchanged. (B) doubles.
(C) is halved. (D) is four times as large.

7. An astronaut floating inside an orbiting spacecraft is often called weightless. The best physical description is that **[3 pts]**

(A) there is no gravitational force on her at that altitude.
(B) the gravitational force is the only force on her, so nothing presses on her.
(C) her mass has become zero.
(D) the spacecraft shields her from the Earth's gravitational field.

8. A tunnel is bored through the center of a uniform planet. As an object released at the surface falls toward the center, the gravitational force on it **[3 pts]**

(A) grows as $\frac{1}{r^2}$.
(B) stays constant.
(C) falls in proportion to r and reaches zero at the center.
(D) falls as $\frac{1}{r^2}$ and reaches zero at the center.

Part B. Problems. All three required. The method carries most of the marks, so show the relationship before you put numbers into it. Point values are marked on each part. 20 points each, 60 points total. About 23 minutes.

9. Two blocks hang from an ideal string that runs over an ideal pulley: $m_1 = 3.0$ kg on the left and $m_2 = 5.0$ kg on the right. They are released from rest. **[20 pts]**

(a) Draw a free-body diagram for each block and write the second law for each, stating your positive direction. **[5 pts]**

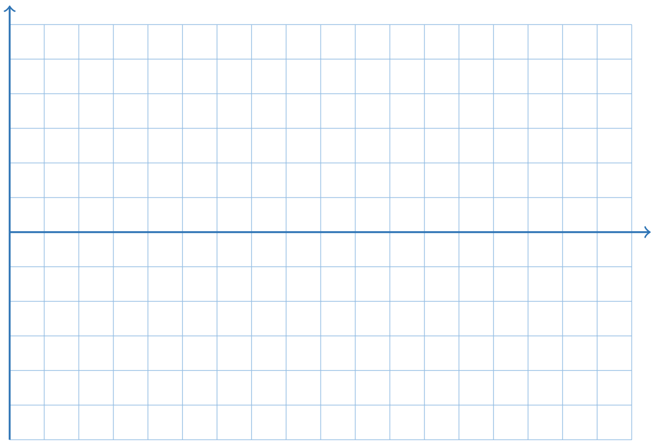
(b) Find the acceleration of the blocks and the tension in the string. **[5 pts]**

(c) Find the acceleration of the center of mass of the two blocks, as a vector. **[5 pts]**

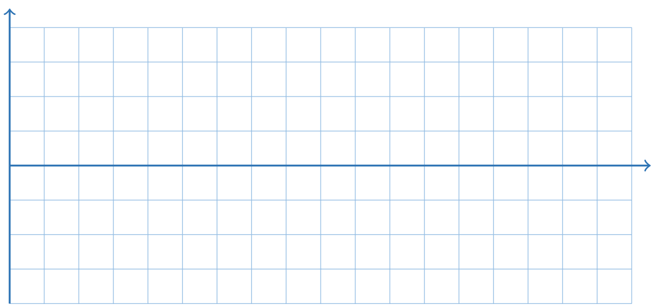
(d) Explain why that answer is not zero even though the two blocks have accelerations of equal magnitude in opposite directions. **[5 pts]**

10. A 3.0 kg object starts at rest at the origin on a frictionless horizontal surface. The only horizontal force on it acts along x and is $+12$ N from $t = 0$ to $t = 2.0$ s, zero from $t = 2.0$ s to $t = 4.0$ s, and -6.0 N from $t = 4.0$ s to $t = 6.0$ s. **[20 pts]**

(a) Sketch the horizontal force against time on the upper half of the grid, labeling both axes. **[5 pts]**



(b) Directly beneath it, on the same time axis, sketch the acceleration against time. **[5 pts]**



(c) Find the velocity at $t = 2.0$ s, at $t = 4.0$ s and at $t = 6.0$ s. **[5 pts]**

(d) Sketch the velocity against time as well, and state the instant between $t = 0$ and $t = 6.0$ s at which the object is farthest from the origin. **[5 pts]**

11. A uniform rope of mass 4.0 kg and length 5.0 m hangs from a ceiling. A 6.0 kg block hangs from the lower end of the rope. Everything is at rest. **[20 pts]**

(a) Find the tension at the very bottom of the rope, where it meets the block. **[5 pts]**

(b) Find the tension a distance y above the bottom of the rope, as a function of y. **[5 pts]**

(c) Find the tension where the rope meets the ceiling, and say why an ideal string would not behave this way. **[5 pts]**

(d) The block is removed and the rope hangs alone. Find the tension at the ceiling and at the midpoint of the rope. **[5 pts]**

Part C. Explain the physics. Answer one of the two. Cross out the one you do not want graded; if you leave both uncrossed, only the first is graded. 16 points. About 8 minutes.

12. State the two parts of Newton's shell theorem. Then explain why the gravitational force inside a uniform solid sphere is proportional to r rather than to $\frac{1}{r^2}$, and say what kind of motion an object dropped into a tunnel through the center would perform. **[16 pts]**

13. Newton's second law is stated in this course as a law about the center of mass of a system. Explain what that adds to the ordinary statement, and use it to describe what happens to a gymnast's center of mass during a somersault in mid-air, ignoring air resistance. **[16 pts]**

First answer. Question number: ________