PHY 201: Space, Time and Motion
Spring 2019, Final exam
Use $g = 10$ m/s^2, $c = 300,000$ km/s.
No electronic devices.

Exam, Form: A

Name: _____

Student Number: _____

TA: _____

Date: _____

Section 1. Matching of scientific terms and concepts (6 pts.)

_____ disdain
_____ centrifugal
_____ conspire
_____ impinge
_____ evade
_____ unequivocal
_____ radial
_____ perihelion
_____ vulgar
_____ abberation
_____ distend
_____ celerity
_____ parallax
_____ pervade
_____ disparity
_____ spurious
_____ chord
_____ omnipresent
_____ metaphor
_____ fathom
_____ celestial
_____ aphelion
_____ lucid
_____ stipulation

(a) swell or cause to swell by pressure from inside
(b) not being what it purports to be; false or fake
(c) the effect whereby the position or direction of an object appears to differ when viewed from different positions
(d) expressed clearly; easy to understand
(e) leaving no doubt; unambiguous
(f) the point in the orbit of a planet, asteroid, or comet at which it is closest to the sun
(g) moving or tending to move away from a center
(h) positioned in or relating to the sky, or outer space as observed in astronomy
(i) swiftness of movement
(j) a great difference
(k) in ordinary use, used by "the many"
(l) a group of notes sounded together, as a basis of harmony
(m) something that deviates from the normal way
(n) the feeling that someone or something is unworthy of one's consideration or respect; contempt
(o) spread through and be perceived in every part of
(p) the point in the orbit of a planet, asteroid, or comet at which it is furthest from the sun
(q) diverging in lines from a common center
(r) a condition or requirement that is specified or demanded as part of an agreement
(s) a unit of length equal to six feet
(t) present everywhere at the same time
(u) strike

(v) a thing regarded as representative or symbolic of something else, especially something abstract

(w) escape or avoid, especially by cleverness or trickery

(x) seem to be working together to bring about a particular result,

Section 2. Multiple choice (29pts.)

1. In order to raise the pitch of a guitar string by one octave, one can
   (a) halve the length of the string
   (b) halve the tension in the string
   (c) double the length of the string
   (d) double the density of the string
   (e) none of the above
2. You are waiting on your bicycle for the race to start. When the starting gun fires, you step on the pedal to accelerate your bike. The frictional force exerted by the road on the tires is
   (a) forward on the front wheel; backward on the back wheel
   (b) forward on the back wheel; backward on the front wheel
   (c) forward on the front and back wheels
   (d) backward on the front and back wheels
3. The moon gravitates towards the earth. Saturn's moons gravitate towards the Saturn. The five known planets gravitate towards the sun. Therefore all bodes are endowed with gravitation. This is an example of
   (a) inductive reasoning
   (b) deductive reasoning
   (c) the principle of sufficient reason
   (d) the principle of non-contradiction
   (e) the principle of parsimony (or Okham's razor)
4. An astronaut aboard a space ship wears a wristwatch which beeps once every minute. According to an observer who watches the ship race by at $0.6c$, the astronaut's wristwatch beeps once every
   (a) 40 seconds
   (b) 75 seconds
   (c) 90 seconds
   (d) 100 seconds
   (e) none of the above
5. The *Pequod*, a whaling ship from Nantucket, sails due east at 10 km/hr with respect to the sea. *Moby Dick*, the great white whale, swims westward at a speed of 5 km/hr with respect to the *Pequod*. What is the speed of *Moby Dick* with respect to *Captain Ahab*, who hobbles westward across the deck of the *Pequod* at 2 km/hr, shaking his fist and cursing?
   (a) 7 km/hr eastward
   (b) 3 km/hr eastward
   (c) 3 km/hr westward
   (d) 7 km/hr westward
   (e) none of the above

6. Two forces, four newtons and six newtons, act simultaneously on a two kilogram mass. What is the *maximum* acceleration of this mass?

   (a) zero
   (b) 1 m/s^2
   (c) 3 m/s^2
   (d) 5 m/s^2
   (e) none of the above

7. The mass of Mercury is about 5% that of Earth; its radius is about 40% that of earth. What would be the acceleration of a rock dropped near Mercury's surface?

   (a) about 1 m/s^2
   (b) about 3 m/s^2
   (c) about 10 m/s^2
   (d) about 30 m/s^2
   (e) it depends on the rock's mass

8. Newton's concept of "inherent force" is most closely linked to the concept of

   (a) inertia
   (b) viscosity
   (c) acceleration
   (d) gravitation
   (e) action

9. A wedge is used to split wood. In order to achieve a mechanical advantage, the angle of the tip of the wedge (from face to face) must be sharper than

   (a) 10 degrees
   (b) 30 degrees
   (c) 45 degrees
   (d) 90 degrees
   (e) 120 degrees

10. A bucket resting on the floor of an elevator contains an incompressible fluid of density ρ. When the elevator has an upward acceleration of magnitude a, the pressure difference between two points in the fluid separated by a vertical distance h is given by:

    (a) $\rho a h$
    (b) $\rho g h$
    (c) $\rho(g + a)h$
    (d) $\rho(g - a)h$
    (e) $\rho g a h$

11. The area under an acceleration vs. time graph is a measure of

    (a) distance
    (b) acceleration
    (c) change in acceleration
    (d) velocity
    (e) change in velocity

12. The electricity of Wauwatosa is to be generated by a power plant which plans to turn all of the mass of a 100 gram golf ball into electrical power. The city consumes about 10^{13} Joules of energy each year. For about how long can the city be powered by the golf ball?

    (a) one week
    (b) one month
    (c) one year
    (d) one century
    (e) ten centuries

13. Newton did not appeal to Kepler's third law of planetary motion in deriving the centripetal force acting upon Earth's moon because

    (a) The center of gravity of the Earth-moon system moves in an ellipse around the sun.
    (b) Earth's moon is acted on by *all* of the planets, not just the Earth.
    (c) Earth's moon is too small.
    (d) Earth has only one moon.
    (e) none of the above

14. A box full of water has two openings on its top surface which are fitted with movable pistons (like in Pascal's *Treatise on the Equilibrium of Fluids*). The left hole has twice the area as the right hole. A four pound weight is placed atop the right piston. What weight should be placed atop the left piston to assure equilibrium?

    (a) one pound
    (b) two pounds
    (c) four pounds
    (d) eight pounds
    (e) none of the above

15. A crescent moon can appear directly overhead to an observer standing on Earth

    (a) around sunset
    (b) at midnight
    (c) around sunrise
    (d) around mid-day
    (e) any of the above are, in fact, possible

16. In order to increase the weight which can be hung from the end of a (massless) beam protruding horizontally from a wall by a factor of eight one can

    (a) double the length of the beam
    (b) halve the length of the beam
    (c) quarter the length of the beam
    (d) double the diameter of the beam
    (e) halve the diameter of the beam

17. A projectile is fired upward by a cannon which is resting on a level field. The projectile's horizontal and vertical velocities are 50 m/s and 20 m/s, respectively. Neglecting air resistance, what is the approximate range of the projectile?

    (a) 100 m
    (b) 200 m
    (c) 400 m
    (d) 800 m
    (e) none of the above

18. Two balls are dropped from rest in a tank of pure water. One falls much faster than the other. This makes sense if

    (a) The balls have the same density but the fast one is much smaller.
    (b) The balls have the same density but the fast one is much larger.
    (c) The balls have the same size, but the fast one has a lower density.
    (d) The balls have the same size and density, but the fast one is a different color.
    (e) This is impossible. All balls fall at the same rate no matter what.

19. Which of the following measured quantities does *not* depend of the size of the object?

    (a) the perimeter of a square
    (b) the surface area of a cube
    (c) the volume of a tetrahedron
    (d) the sum of the interior angles of a triangle
    (e) the *ratio* of the volume and the surface area of a sphere

20. According to Pascal, which of the following were errors which rendered a correct understanding of the adhesion of bodies absolutely impossible?

    (a) air has no weight
    (b) elements (such as water) have no weight (when submerged) in themselves
    (c) fluids may be raised to any height whatsoever by means of a pump
    (d) all of the above
    (e) none of the above

21. Two 1-kg masses are suspended at equal distances from the fulcrum of a balance. One is a cube of solid copper; the other is a cube of solid lead. The balanced is then submerged in an aquarium full of water. Consequently,

    (a) the scale will still be balanced.
    (b) the copper cube will rise and the lead cube will fall.
    (c) the lead cube will rise and the copper cube will fall.
    (d) which cube rises will depend on the density of the water in the aquarium
    (e) Wait. There is no way these cube could have been balanced in the first place, since they are made of different materials.

22. For a uniformly accelerating object,

    (a) the distance traveled is proportional to the time of fall
    (b) the speed is proportional to the distance of fall
    (c) the speed is proportional to the time of fall
    (d) all of the above
    (e) none of the above

23. In which of the following cases would you expect to see the lowest-Reynolds number flow?

    (a) a teaspoon gently stirring cream into a cup of steaming black coffee
    (b) a lone hawk soaring high above an ancient gnarled forest
    (c) a nuclear submarine cruising silently through the deep
    (d) a .308 caliber bullet slicing through the cool night air
    (e) a tiny amoeba wiggling about in a warm swamp

24. A projectile is fired in a vacuum from a flat surface with an initial horizontally speed of 40 m/s and a vertical speed of 30 m/s. What is the speed of the projectile at the apogee (highest point) of its flight?

    (a) 0 m/s
    (b) 30 m/s
    (c) 40 m/s
    (d) 50 m/s
    (e) none of the above

25. Which of the following is *not* one of Kepler's laws of planetary motion?

    (a) Planets orbit the sun in elliptical orbits; the sun is at one of the foci of each ellipse.
    (b) Planets sweep out equal areas in equal increments of time.
    (c) The orbital period of each planet is proportional to the 3/2 power of the orbital semidiameter.
    (d) The planets are attracted to the sun by a force which varies as the inverse square of the distance from the sun.
    (e) Actually, all of these are Kepler's laws.

26. Serena rests in the caboose of a westbound train, while Venus sits in the engine car. Another, eastbound, train approaches Venus and Serena's train. The conductor of the eastbound train wears a large wristwatch. Which of the following statements about the wristwatch is true?

    (a) Venus sees the wristwatch ticking faster than Serena because she is closer to it.
    (b) Venus sees the wristwatch ticking faster than the conductor himself due to the effect of time dilation.
    (c) Venus and Serena see the wristwatch ticking at the same rate as the conductor.
    (d) Venus and Serena see the wristwatch ticking at the same rate as each other because they occupy the same inertial reference frame.
    (e) none of the above

27. Let F_1 be the gravitational force exerted on an apple by the earth and F_2 be the gravitational force exerted on the earth by the apple.

    (a) F_1 is much greater than F_2.

    (b) F_1 is slightly greater than F_2.

    (c) F_1 is equal to F_2.

    (d) F_1 is slightly less than F_2.

    (e) The forces F_1 and F_2 depend on whether a third mass is present.

28. Galileo derived the principle of the lever beginning from what axiom?

    (a) Equal weights at equal distances are in equilibrium.

    (b) Unequal weights are out of balance at unequal distances.

    (c) Archimedes' principle.

    (d) Pascal's principle.

    (e) none of the above

29. A body with mass two and speed three approaches a stationary body of mass five. What is the speed of the center of gravity of this two-body system?

    (a) 1/3

    (b) 1/2

    (c) 3/2

    (d) 3/4

    (e) none of the above.

Section 3. Pendulum in an elevator (6 pts.)

Consider a one-kilogram mass suspended by a one-meter long cord from the ceiling of a stationary elevator. You now use your hand to pull horizontally on the mass until the string makes a 45 degree angle from its natural (vertical) position.

1. Draw a free body diagram depicting all of the forces acting on the mass while suspended in this way. What is the net (total) force acting on the mass?

2. What is the weight of the mass (in Newtons). What is the tension exerted by the string? And what is the (horizontal) force required to hold it at this 45-degree angle?

3. Now suppose that the elevator begins to accelerate upwards at a constant rate of ten meters per second per second. By how much do (i) the apparent weight, (ii) the tension in the cord, and (iii) the force required to maintain the string at a 45 degrees angle change (if at all)?

4. Suppose that, while the elevator is still accelerating upwards, the mass is suddenly released. Draw a free-body diagram depicting the forces acting on the mass a moment later—precisely as it passes through the bottom of its swing. Is the net (total) force acting on the mass at this moment zero? If not, then in which direction does the net force point?

5. Is the period of oscillation of this pendulum the same as that of an identical pendulum swinging in a non-accelerating elevator? If not, then by what factor is it longer (or shorter)?

6. If you were enclosed in an elevator with no windows, would it be possible—by observing a swinging pendulum—to discern whether the elevator was in fact (a) accelerating upward at a rate of 10 m/s^2 away from the Earth's surface, or (b) remaining stationary on the surface of a planet whose gravitational acceleration was twice as strong as that of the Earth? If so, how?

Section 4. Earth's moon essay (4 pts.)

1. Why does the moon orbit the earth? More importantly: how do you know? Provide a compelling case for your personal belief using neat handwriting, logical and relevant principles or formulae, and correct grammar, spelling and punctuation. Note: simply referring to "gravity" or to "modern science" will get you little or no credit; you need to defend *why* you believe what you do.