Name: Spring 2024, Final exam

PHY 151/201 General Physics 1 $g = 10$ m/s^2 or 32 ft/sec^2

Section 1. Matching of scientific terms and concepts; some definitions on next page (6 pts.)

_____ aphelion
_____ occult
_____ circumjovial
_____ discern
_____ disdain
_____ adhesion
_____ cartesian
_____ hitherto
_____ scholium
_____ contrivance
_____ stipulation
_____ perihelion
_____ parity
_____ defile
_____ fathom
_____ impediment
_____ innate
_____ tedious
_____ chord
_____ mallet
_____ spurious
_____ thence
_____ immutable
_____ celestial

(a) an explanatory comment or discussion
(b) a thing which is created skillfully to serve a particular purpose
(c) unchangeable
(d) inborn; natural
(e) conceal from view
(f) up until now
(g) perceive or recognize (something)
(h) the point in an orbit nearest to the sun
(i) a condition or requirement that is specified or demanded as part of an agreement
(j) a hindrance or obstruction in doing something
(k) a hammer with a large wooden head
(l) relating to the sky or the heavens
(m) a unit of length equal to six feet
(n) not being what it purports to be; false or fake
(o) spoil, desecrate, or profane
(p) tiresome or monotonous
(q) sticking together of different substances.
(r) relating to Descartes and his ideas
(s) consider to be unworthy of one's consideration
(t) orbiting Jupiter
(u) the point in an orbit furthest from the sun
(v) a straight line joining the ends of an arc.
(w) from there
(x) the state or condition of being equal

Section 2. Multiple choice (36 pts.for PHY 151; 41 pts.for PHY 201)

1. According to Pascal, in which of the following fields of study must one defer to authority (as opposed to experiment)?
   (a) history
   (b) theology
   (c) geography
   (d) languages
   (e) all of the above
2. According to Pascal, nature abhors a vacuum most
   (a) on mountaintops
   (b) in wet weather
   (c) in a belfry
   (d) in a yard
   (e) wait a minute: Pascal thinks that nature is inanimate and cannot abhor anything
3. A tiny bubble ascends from the bottom of a glass of champagne. By the time it gets to the top of the glass, its volume has doubled. By what factor has its radius increased?
   (a) 8
   (b) 5
   (c) 2
   (d) $2^{1/2}$
   (e) $2^{1/3}$
4. What is the maximum height that one can draw water from a pond into a vertical tube using a vacuum pump near earth's surface?
   (a) 100 mm
   (b) 760 mm
   (c) 7.6 m
   (d) about 10 m
   (e) there is no limit
5. When an object's velocity is plotted as a function of time, the area under a velocity vs. time graph provides a measure of the
   (a) change in acceleration of the object
   (b) distance travelled by the object
   (c) change in velocity of the object
   (d) acceleration of the object
   (e) velocity of the object

6. Suppose that a distant star is found to be orbited by several planets at different distances. If the orbital periods, T, of these planets is found to scale as the orbital distances, r, to the 5/2 power, then the centripetal forces holding these planets in orbit must obey:

   (a) $F \propto r^{3/2}$

   (b) $F \propto 1/r$

   (c) $F \propto 1/r^2$

   (d) $F \propto 1/r^3$

   (e) $F \propto 1/r^4$

7. **PHY 201 students:** What is the main point of Aristotle's wheel paradox, to which Galileo refers in discussion of rolling polygons and rolling wheels?

   (a) a circle is comprised of an infinite number of points, so matter can also consist of an infinite number of atoms

   (b) the sum of the internal angles of any polygon is 360 degrees

   (c) it is impossible to know for sure if an object is truly spinning

   (d) spinning objects are held together by a centripetal force

   (e) wheels experience no friction while rolling

8. A circular-cross-section beam projects horizontally from a vertical wall. The weight of the beam exerts a moment (torque) that tries to break the beam. In order to exactly quadruple this torque, one could

   (a) double the density of the beam

   (b) double the diameter of the beam

   (c) quadruple the length of the beam

   (d) simultaneously double the diameter and the length of the beam

   (e) none of the above

9. **PHY 201 students:** An initially stationary disk acquires a constant angular acceleration, $\alpha = 3$ rad/second^2. By what angle, θ, has it rotated in 4 seconds?

   (a) 3 radians

   (b) 4 radians

   (c) 24 radians

   (d) 33 radians

   (e) none of the above

10. **PHY 201 students:** Suppose that a detonation causes an initially stationary 100 kg mass to break in half. The total kinetic energy created in this explosion is 200 joules. The two halves move

    (a) in opposite directions, each at 1 m/s

    (b) in opposite directions, each at 2 m/s

    (c) in opposite directions, but with different speeds

    (d) in the same direction, at the same speed

    (e) in the same direction, but with different speeds

11. A 3 gram weight is placed on the left side of a lever; an 8 gram weight on the right. The lever is 22 cm long. Where must be the fulcrum for equilibrium?

    (a) 8 cm from the 3 gram weight

    (b) 11 cm from the 3 gram weight

    (c) 16 cm from the 3 gram weight

    (d) 18 cm from the 3 gram weight

    (e) none of the above

12. You are trapped at the bottom of the sea in Captain Nemo's submarine, the *Nautilus*. You wish to escape. There are four identical outward-swinging portals: one on the top, one on the bottom, one on the starboard (right) side, and one on the port (left) side. Which will take the least force to open?

    (a) the top one

    (b) the bottom one

    (c) the starboard one

    (d) the port one

    (e) they all take the same force to open

13. Which is generally more effective in breaking a stick: a longitudinal or a transverse force?

    (a) longitudinal

    (b) transverse

14. In his discussion of harmony, Galileo claimed that

    (a) harmonious notes are related by ratios of small integers, such as 2 to 3

    (b) the frequencies of discordant notes cannot be expressed as a ratio of integers

    (c) listening to harmonious notes is a bit like observing the patterns of swinging pendulae

    (d) all of the above

    (e) none of the above

15. If the mass of the moon were suddenly halved, the gravitational force of the moon acting on the Earth would

    (a) double

    (b) remain the same

    (c) be halved

    (d) be different than the force of the Earth acting on the moon

    (e) none of the above

16. Galileo, in his *Dialogues*, discusses "Two New Sciences." To which of the following is he referring in the title? (circle two)

    (a) the strength of materials

    (b) planetary motion

    (c) the new theory of atomism

    (d) projectile motion

    (e) the weight of air

17. In Galileo's' proof of the law of the lever (that he borrowed from Archimedes), which of the following did he assume to be true?

    (a) the longitudinal resistance of a rod is proportional to its cross sectional area

    (b) equal weights at equal distances from a fulcrum are in equilibrium

    (c) the supporting moment of a rod depends on the rod's diameter

    (d) unequal weights at unequal distances are in equilibrium

    (e) all of the above

18. A fluid-filled cylindrical syringe has a needle that is 1 mm in diameter; it is fitted with a plunger that is 1 cm in diameter. When the plunger is depressed with a force of 1 pound, what is the minimum force required to plug the needle so that fluid does not escape?

    (a) 0.001 pound

    (b) 0.01 pound

    (c) 0.1 pound

    (d) 1 pound

    (e) 10 pounds

19. The *centripetal acceleration*—what Newton calls the "accelerative quantity of centripetal force"— of an object traveling at speed v in a circle of radius r is given by

    (a) $\frac{v}{r}$

    (b) $\frac{v^2}{r}$

    (c) $\frac{v}{r^2}$

    (d) $m\frac{v^2}{r}$

    (e) none of the above

20. If a ball falls one unit of distance during its first second of fall (in a vacuum), then how many units of distance does it fall during its fourth second of fall?

    (a) 1

    (b) 3

    (c) 4

    (d) 5

    (e) 7

21. The velocity of an object that is dropped (in a vacuum) is proportional to

    (a) the time of descent

    (b) the distance fallen

    (c) the square of the time of descent

    (d) the square of the distance fallen

    (e) none of the above

22. **PHY 201 students:** According to the barometric formula, the atmospheric pressure

    (a) decreases linearly with altitude

    (b) decreases exponentially with altitude

    (c) does not vary with altitude

    (d) increases linearly with altitude

    (e) increases exponentially with altitude

23. When the *tension* of a guitar string is doubled (everything else remaining the same), its oscillation frequency (when plucked) will

    (a) be quartered

    (b) be halved

    (c) remain the same

    (d) be doubled

    (e) none of the above

24. **PHY 201 students:** Suppose the acceleration of an object is *not* constant. Rather, its acceleration *increases* with time according to $a(t) \propto t$. This object's velocity $v(t)$ depends on time according to:

    (a) $v(t) \propto t^3$

    (b) $v(t) \propto t^2$

    (c) $v(t) \propto t$

    (d) $v(t) \propto 1/t$

    (e) actually, the velocity is constant

25. Suppose you are riding at a constant velocity on the Siberian railway. You decide to amuse yourself by tossing an apple straight up into the air and catching it as it falls straight down into your hand. This works because of

    (a) the principle of relativity.

    (b) Archimedes principle.

    (c) Pascal's principle.

    (d) Newton's third law.

    (e) Kepler's first law.

26. By means of his rotating bucket thought-experiment, Newton argued that

    (a) time passes at different rates according to different people

    (b) absolute rotational motion is experimentally measurable

    (c) absolute linear motion is experimentally measurable

    (d) moving objects are shorter than stationary objects

    (e) only relative motion is ever measurable

27. With which of the following statements would Newton agree?

    (a) we should admit no more causes in nature than are both true and sufficient to explain appearances

    (b) to the same natural effects, we should assign the same causes, insofar as possible

    (c) the existence of absolute space can be inferred from observing rotating bodies

    (d) God exists always and everywhere, but has no body

    (e) all of the above

28. Suppose you lived on a planet that had twice the mass and twice the radius of earth. What would be the acceleration of gravity near the planet's surface?

    (a) 1 m/s^2

    (b) 2 m/s^2

    (c) 5 m/s^2

    (d) 20 m/s^2

    (e) none of the above

29. When Venus appears to be in its "new" phase, it will be

    (a) nearest the earth

    (b) furthest from the earth

    (c) nearest the sun

    (d) furthest from the sun

    (e) any of these are, in fact, possible

30. Two identical solid gold balls are suspended by identical threads from the ceiling. Ball one is pulled back by 10 degrees; ball two by 20 degrees. Which ball will swing through the bottom with a greater speed?

    (a) 1

    (b) 2

    (c) neither (same speed)

31. Norah rides on a train traveling at 30 mph northward. Susan rides on a train traveling 50 mph southward. Walter is walking southward inside the northbound train at 4 mph. What is the speed of Walter with respect to Susan?

    (a) 84 mph northward

    (b) 76 mph northward

    (c) 34 mph northward

    (d) 26 mph southward

    (e) none of the above

32. An 40 kg object is sliding eastward at 20 m/s. It catches up to and collides with a 60 kg object which was originally sliding eastward at 10 m/s. The objects stick together. What is the final speed of the two blocks (in m/s)?

    (a) 14

    (b) 36

    (c) 80

    (d) 125

    (e) none of the above

33. Two pebbles of the same shape and material (but different sizes) are dropped in a pool of water. Which will fall more quickly through the water?

    (a) The small one, because drag affects it more.

    (b) The small one, because the buoyant force is greater.

    (c) The large one, because drag affects it less.

    (d) The large one, because the buoyant force is greater.

    (e) Neither: they will both fall at the same speed.

34. (2 points) A projectile is fired at a 60 degree angle (above the horizontal) by a cannon which is resting on a level field. The muzzle velocity is 80 m/s. What is the range of the projectile?

(a) 48 m

(b) $40\sqrt{2}$ m

(c) $320\sqrt{3}$ m

(d) 640 m

(e) none of the above

35. An astronaut aboard a space ship wears a wristwatch that beeps once every minute. According to an observer who watches the ship race by at $0.8c$, the astronaut's wristwatch beeps once every

(a) 40 seconds

(b) 75 seconds

(c) 90 seconds

(d) 100 seconds

(e) none of the above

36. A 1 cubic cm solid ball of copper (sp.gr.9) and a 1 cubic cm solid ball of gold (sp.gr.19) are hung by strings and dipped into a water-filled aquarium. If the threads are cut, which will accelerate more?

(a) the gold

(b) the copper

(c) neither (they experience the same acceleration)

(d) it is impossible to tell

37. In proving that a body subject to a centripetal force must sweep out an area proportional to time, Newton employed his

(a) first law of motion alone

(b) first and third laws of motion alone

(c) first and second laws of motion alone

(d) second and third laws of motion alone

(e) first, second and third laws of motion

38. A 1 cubic cm solid ball of copper (sp.gr.9) and a 1 cubic cm solid ball of gold (sp.gr.19) are hung by strings and dipped into a water-filled aquarium. Which feels a larger buoyant force?

(a) the gold

(b) the copper

(c) neither (same buoyant force)

(d) it is impossible to tell

39. Three two-Newton forces act simultaneously on a two kilogram mass. What is the *maximum* acceleration of this mass?

(a) zero

(b) 1 $\mathrm{m/s^2}$

(c) 3 $\mathrm{m/s^2}$

(d) 6 $\mathrm{m/s^2}$

(e) none of the above

40. Newton's definition of "quantity of motion" is most similar to our definition of

(a) momentum

(b) centripetal force

(c) gravitational force

(d) inertia

(e) mass

Section 3. The spinning terror (8 pts.)

The *spinning terror* is an amusement park ride consisting of a large vertically-oriented cylindrical chamber. You and the other passengers walk into the chamber and stand on the floor with your backs against the curved wall. The chamber then begins to spin faster and faster until the floor is lowered and you and the other passengers remain stuck to the wall, suspended above the floor! In this problem, you will analyze this situation from a scientific perspective, making use of Newton's laws.

1. Imagine looking at the person stuck to the wall next to you (let's call him Ralph). Draw a free body diagram indicating the directions of the three forces–gravitation, normal force, and friction force—acting on Ralph. Is there a net force on him? If so, in which direction?

2. For each of the three forces above, clearly identify and describe its equal and opposite force (in the sense of Newton's third law). Be sure to indicate the object on which each of these forces acts.

3. Suppose the chamber has a radius $R = 5$ meters and spins around once every second. What is Ralph's speed?

4. What is Ralph's centripetal acceleration? Is this larger or smaller than the value of g?

5. If Ralph has a mass of $M = 50$ kilograms, what is the value of the normal force exerted by the wall on Ralph?

6. What is the minimum value of the coefficient of friction, μ, between Ralph and the wall so that he does not slide down the wall?

7. Assuming the same coefficient of friction you found in the previous question, would you slide down the wall if your mass is twice that of Ralph? Explain.

8. Challenge question: Ralph, with his back pressed to the wall, holds a tiny marble 10 cm in front of his face. When he releases the marble, how many seconds would it take to strike his forehead?

Section 4. Laboratory essay (5 pts.)

1. Describe your favorite laboratory experiment this semester. Be sure to clearly and concisely describe what you did, how you analyzed the data, and what you learned from the experiment. You must use clear handwriting, correct grammar and spelling, and graceful and convincing style.