Name: $g = 10$ m/s^2 or 32 ft/sec^2

Section 1. Matching of scientific terms and concepts; some definitions on next page (5 pts.)

_____ indignation

_____ unity

_____ centrifugal

_____ invincible

_____ suffice

_____ chimerical

_____ vulgar

_____ stipulation

_____ circumspect

_____ digression

_____ augment

_____ unequivocal

_____ perihelion

_____ celerity

_____ omnipresent

_____ parallax

_____ tympanum

_____ aphelion

_____ fallacious

_____ innumerable

_____ celestial

_____ laden

_____ tenacity

_____ aperture

_____ league

(a) a condition or requirement that is specified or demanded as part of an agreement

(b) based on a mistaken belief

(c) leaving no doubt; unambiguous

(d) the quality or fact of being able to grip something firmly

(e) in ordinary use, used by "the many"

(f) too powerful to be defeated or overcome

(g) swiftness of movement

(h) the point in the orbit of a planet, asteroid, or comet at which it is closest to the sun

(i) too many to be counted

(j) a former measure of distance by land, usually about three miles

(k) a thing that is hoped or wished for but in fact is illusory or impossible to achieve

(l) be enough or adequate

(m) the effect whereby the position or direction of an object appears to differ when viewed from different positions

(n) anger or annoyance provoked by what is perceived as unfair treatment

(o) a temporary departure from the main subject in speech or writing

(p) make (something) greater by adding to it; increase

(q) a drum

(r) positioned in or relating to the sky, or outer space as observed in astronomy

(s) present everywhere at the same time

(t) an opening, hole, or gap

(u) the number one

(v) heavily loaded or weighed down

(w) moving or tending to move away from a center   comet at which it is furthest from the sun

(x) the point in the orbit of a planet, asteroid, or   (y) wary and unwilling to take risks

Section 2. Multiple choice (25 pts.)

1. A small chunk of solid copper is suspended from one arm of a balance (like you did in lab). A mass of 9 grams placed in the other arm of the balance will establish equilibrium. When the suspended copper chunk is now completely submerged in a graduated cylinder full of water, how many grams will be required to balance the scale?

   (a)   10
   (b)   9
   (c)   8
   (d)   7
   (e)   none of the above will balance the scale

2. When a ball is dropped from rest, it travels a distance of one javelin-length when it falls for *one* heart-beat. How many javelin-lengths will it travel when falling for *three* heart-beats?

   (a)   1
   (b)   3
   (c)   5
   (d)   9
   (e)   none of the above

3. Which of the following celestial objects exhibits the largest angular elongation from the sun when viewed from Earth?

   (a)   Mercury
   (b)   Venus
   (c)   Mars
   (d)   all of the above
   (e)   none of the above

4. Seeking to slay Goliath, David swings a 100 gram rock in a circular orbit above his head using a 10 cm long sling made of leather. The leather will snap if the tension exceeds 100 Newtons. Approximately how fast can David swing the rock without breaking the sling?

   (a)   10 m/s
   (b)   20 m/s
   (c)   40 m/s
   (d)   100 m/s
   (e)   over 100 m/s

5. Suppose that the orbital semi-diameters of two circum-jovial moons have a ratio of 4 to 1. The orbital periods to these moons have a ratio of

   (a)   1 to 1
   (b)   2 to 1
   (c)   4 to 1
   (d)   8 to 1
   (e)   none of the above

2

6. A cylindrical glass tube, one inch in diameter and 100 inches long, is bent into a U-shape. Mercury is poured into the tube until it is half way up each arm of the tube. Ten inches of alcohol are then poured gently into the left arm. What is the height of the mercury in the right arm, as measured from the level of the mercury-alcohol interface in the left arm?

   (a)   0 in.

   (b)   about 4/7 in.

   (c)   about 2 in.

   (d)   about 14/3 in.

   (e)   about 14 in.

7. An astronaut aboard a spaceship watches a large spherical asteroid pass his ship at about 60% the speed of light. To measure its diameter, he measures the time it takes to pass: four microseconds from the front to the back of the asteroid. What is the diameter of the asteroid as measured by another astronaut who is riding atop it?

   (a)   1 meter

   (b)   300 meters

   (c)   900 meters

   (d)   1800 meters

   (e)   none of the above

8. Three forces act on a 2 kg mass which is initially at rest. An eastward force of 2 N; a westward force of 2 N; and a northward force of 3 N. Make a free-body diagram for this object. Then answer: what is the speed of this object after four seconds?

   (a)   1 m/s northward

   (b)   3 m/s northward

   (c)   4 m/s northward

   (d)   6 m/s northward

   (e)   none of the above

9. As a bubble of air ascends from the bottom of a glass of beer, its radius increases. Which of the following quantities increase most rapidly during its ascent?

   (a)   its radius

   (b)   its diameter

   (c)   its surface area

   (d)   its volume

   (e)   its density

10. The driver of a rear-wheel drive Porsche, sitting patiently at a stop sign, suddenly hits the gas pedal. The frictional force which the road exerts on the wheels is now

   (a)   forward for the front wheels and forward for the back wheels

   (b)   forward for the front wheels and backward for the back wheels

   (c)   backward for the front wheels and forward for the back wheels

   (d)   backward for the front wheels and backward for the back wheels

11. In order to sharpen the note played by a stretched string by one octave, one might

    (a)   lengthen the string by a factor of two

    (b)   quadruple the tension in the string

    (c)   halve the weight of the string

    (d)   all of the above

    (e)   none of the above

12. Tin is one thousand times denser than air and ten times denser than water. Ignoring the effects of drag, how does the acceleration of a solid tin sphere when dropped in air compare to the same sphere's initial acceleration when dropped in water?

    (a)   900:999

    (b)   999:900

    (c)   9:1

    (d)   10:1

    (e)   100:1

13. All bodies about the earth gravitate towards the earth. The moon gravitates towards the earth. All planets gravitate towards one another. 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 relativity

14. Red and a blue simple pendulums are set up side by side in a room. The red pendulum swings three times during each swing of a blue one. The ratio of the *length* of the red pendulum to the blue pendulums is

    (a)   3:1

    (b)   9:1

    (c)   1:3

    (d)   1:9

    (e)   none of the above

15. A spaceship flies toward a planet at 0.2 c. It fires a rocket at the planet at 0.8 c with respect to its cannon. What is the speed of the rocket compared to the planet?

    (a)   1.16c

    (b)   c

    (c) $\frac{1}{1.16}$c

    (d)   0.33c

    (e)   .41c

16. Consider a small plastic syringe. The plunger, in one end, has a cross sectional area of one square centimeter. The needle, in the other end, has a cross sectional area of one square millimeter. If the plunger is depressed using a force of one pound, how much force is exerted by the fluid coming out of the very tip of the needle?

   (a)   1/100 pound

   (b)   1 pound

   (c)   10 pounds

   (d)   100 pounds

   (e)   none of the above

17. In physics lab, you evacuated a bell jar by pumping out the air with a syringe and a one-way valve. The bell jar was then submerged, a port was opened, and water rushed into the jar. The volume of water in the jar

   (a)   equalled the volume of the jar itself

   (b)   equalled the volume of the air that had been removed with the syringe

   (c)   equalled the volume of the air that had *not* been removed with the syringe

   (d)   would be the same, regardless of how many times you pumped the syringe

   (e)   none of the above

18. Suppose that you are walking at 2 mph down the aisle (toward the back) of a train which is traveling northward at 15 mph. The train passes another, southbound, train which is traveling at 8 mph. What is your velocity relative to a person standing on the southbound train.

   (a)   25 mph

   (b)   17 mph

   (c)   13 mph

   (d)   10 mph

   (e)   none of the above

19. A cylindrical beam protrudes horizontally from a vertical wall. If the scale of the beam is doubled (that is: its length and its diameter are both doubled), what happens?

   (a)   its weight doubles

   (b)   its resistance to *longitudinal* fracture doubles

   (c)   the breaking moment (torque) caused by its weight doubles

   (d)   all of the above

   (e)   none of the above

20. A round pebble and a round grain of sand (of the same material) are dropped in a pool of water. Which will fall more slowly?

   (a)   The sand, because drag affects it more.

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

   (c)   The pebble, because drag affects it more.

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

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

21. An object with a volume of one cubic inch is completely submerged in alcohol. The buoyant force exerted by the alcohol on the object is greatest if

    (a)   the object is hollow

    (b)   the object is made of glass

    (c)   the object is made of lead

    (d)   the object is made of aluminum

    (e)   none of the above

22. When Venus is in opposition to the sun (as viewed from the earth), its observed phase is

    (a)   full

    (b)   gibbous

    (c)   half

    (d)   crescent

    (e)   Wait a minute! Venus would never be seen in opposition to the sun.

23. A car travels eastward at constant velocity. The *net* force on the car is:

    (a)   eastward

    (b)   westward

    (c)   up

    (d)   down

    (e)   zero

24. Three forces act on an object. The forces have magnitudes of 1 lb, 2 lbs and 8 lbs. What is the minimum net force acting on the object?

    (a)   0 lbs

    (b)   3 lbs

    (c)   5 lbs

    (d)   11 lbs

    (e)   none of the above.

25. 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)   100 years

    (e)   900 years

Section 3. Projectiles in an elevator (3 pts.)

Suppose that you are riding in a large elevator with no windows. So you cannot tell if you are moving or not. Anyhow, you would like to *at least* know if the elevator is accelerating; and if so, by how much and in which direction. Unfortunately, you do not have a scale (like you did in the final lab of the semester). So you cannot just measure the weight of some object to figure out the acceleration of the elevator. You do, however, have a projectile launcher and a ruler. The projectile launcher fires little steel balls with a muzzle velocity of exactly 3 meters per second. Maybe you can use this to determine if the elevator is accelerating?

1. You fire the launcher horizontally from a height of one meter above the elevator floor. The horizontal range of the ball is measured to be exactly one meter. Using this information, and the fact that $g = 10$ m/s^2 near earth's surface, what is the acceleration of the elevator, in m/s^2? And in which direction?

2. Suddenly, a profound thought occurs to you: "What if I am not really in an accelerating elevator on the surface of Earth?" and "What if I am actually sitting still on the surface of a different planet with a different gravitational acceleration than that of Earth?" Could you determine the mass, M, and the radius, R, of this different planet from your experiments? If so, how? If not, why not? What else might you need to know?

Section 4. Conservation of momentum problem (2 pts.)

Uranium-238, which has a rest mass of 238 atomic mass units, spontaneously breaks apart (decays) into two new atoms: thorium-234 and helium-4. These new atoms have rest masses of about 234 and 4 atomic mass units, respectively. This radioactive decay process is given by the nuclear reaction equation

$$^{238}_{92}\text{U} \longrightarrow \ ^{234}_{90}\text{Th} + \ ^{4}_{2}\text{He} \tag{1}$$

Suppose that the uranium nucleus is initially at rest. When it decays, the helium-4 nucleus shoots out in one direction at a 5% the speed of light.

1. What is the speed and direction of the ejected thorium-234 nucleus? Express your answer in terms of the speed of light; for full credit, you must reduce the fraction in your answer as much as possible. (Advice: since the speeds involved are small compared to the speed of light, there is no need to use relativistic equations.)

Section 5.   PHY 151 students only: (2 pts.)

Consider a one-meter square piece of very thin cardboard placed on the ground so that the corners point in the four compass directions. A mass is placed on each corner. The north and east corners have masses of 3 kg; the south and west corners have masses of 1 kg.

1. Where is the center of mass of this four-mass system? Be sure to explain in terms of how far north, south, east, and west of the center of the square it is located.

Section 6.   PHY 201 students only: (2 pts.)

A 1-meter long straight rod has non-uniform mass density along its length. In particular, its mass-per-until length varies as $\rho(x) = 4x^3$.

1. If you wanted to balance this rod on a fulcrum, then where, exactly, must the fulcrum be placed under the rod?

2. Extra-credit challenge: what if the 1-meter long rod was folded in half at the 50-cm mark, so that it doubles back on itself? Then where would the fulcrum have to be placed under the newly-formed thick 50-cm rod so that it balances?

Section 7. Four causes essay (3 pts.)

1. Using Aristotle's four causes, provide an explanation of a cheeze pizza. Be clear and concise. Which two of these causes do most modern natural scientists focus their attention on?