SOLUTIONS (W Crtx #75)



**[Note: A ten-question (questions 6 through 15) matching table occurs on page 3. Since it might be managed more quickly, you may wish to deal with it early.]**

**Multiple Choice**

*On your NCS answer sheet, fill in the circle of the letter choice that best completes the statement or answers the corresponding question.*

1. If the mass and weight of an astronaut are measured on the earth and on the moon, respectively, his mass will be found to be _____ and his weight, _____.
   a. the same ... the same
   b. different ... different
   c. the same ... larger
   d. different ... the same
   e. the same ...smaller
   f. None of the above completions (a through e) yields a correct statement.

2. Pat and Chris both travel from Los Angeles to New York along the same route. Pat rides a moped while Chris drives a fancy sports car. Unfortunately, Chris's car breaks down in Phoenix for over a week, causing him to arrive in New York just an hour before Pat. Which statement is true?
   a. Pat and Chris had the same average speed.
   b. Chris had the higher average speed.
   c. Pat had the higher average speed.
   d. We don't have enough information to compare their average speeds.
   e. None of the above.

3. If we ignore air resistance, the speed of an object that is falling downward increases at a constant rate. How would the speed change if we do *not* ignore air resistance? As the object falls,
   a. The speed increases at a constant rate.
   b. The speed increases at an increasing rate
   c. The speed increases but at a rate decreasing towards zero
   d. The speed does not change.
   e. The speed decreases at a constant rate.
   f. The speed decreases but at an increasing rate
   g. The speed decreases at a decreasing rate
   h. Not enough information to say.

4. Given that the circumference of the earth's orbit about the sun is 9.4 X $10^8$ km, which calculation gives the correct conversion of a speed of 1 orbit per 365 days to the same speed in meters per sec?
   a. (1orbit/365day)( 9.4X$10^8$km/orbit)(1day/24hr)(3600sec/1hr)($10^3$m/1km) = $m \cdot \frac{sec}{(hr)^2}$ WRONG
   b. (1orbit/365day) (9.4X$10^8$km/orbit)(1day/24hr)(1hr/3600sec)($10^3$m/1km) = m/sec CORRECT
   c. (1orbit/365day) (9.4X$10^8$km/orbit)(24hr/1day)(1hr/3600sec)(1km/$10^3$m) = $\frac{km^2}{m} \cdot \frac{(hr)^2}{sec}$ WRONG
   d. (1orbit/365day) (1orbit/9.4X$10^8$km)(1day/24hr)(1hr/3600sec)($10^3$m/1km) = $(orbit)^2$ ? WRONG
   e. (1orbit/365day) (9.4X$10^8$km/orbit)(1day/24hr)(1hr/3600sec)(1km/$10^3$m) = $\frac{km^2}{m} \frac{(hrs)^2}{sec}$ WRONG
   f. None of the above conversions yields the correct result.

5. If a ball is dropped from rest, it will fall 20 m during the first two seconds. How far will it fall during the second and third seconds combined?

a. 20 m
b. 30 m
c. 40 m
d. 50 m
e. 60 m
f. None of the above answers is within 10% of the correct answer.

$d(t) = \frac{1}{2} a t^2$ $\quad d(3) - d(1) = \frac{1}{2} 10[(9) - 1] = 40m$ during 2nd & 3rd sec

**The next ten questions (#6-#15) request you to match the scientist with his contribution. For each numbered question, fill in the circle on your NCS answer sheet corresponding to the letter describing the person's achievement.**

| | | |
|---|---|---|
| H | **6. Galileo** | **(A.) Showed that atom is nuclear, not pudding-like.** |
| I | **7. Newton** | **(B.) Postulated that only certain selected orbits were allowed for atomic electrons.** |
| F | **8. Joule** | **(C.) His atomic hooks turned out to be electrons extra to or missing from filled electron shells.** |
| J | **9. Carnot** | **(D.) Postulated that energy of light is proportional to its frequency.** |
| G | **10. Avogadro** | **(E.) Postulated Maxwell's laws to be the same in all inertial frames, and that light consists of photon packets.** |
| C | **11. Dalton** | **(F.) Showed that mechanical energy converts to heat always with same fixed ratio.** |
| A | **12. Rutherford** | **(G.) Proposed that each liter of gas (at STP) contained the same number of particles.** |
| E | **13. Einstein** | **(H.) Reversed Aristotle by presenting steady motion as the natural undisturbed state of an object.** |
| D | **14. Planck** | **(I.) Identified acceleration as the result of a net force.** |
| B | **15. Bohr** | **(J.) Designed his ideal heat engine to prove the Second Law of Thermodynamics.** |

**Continue on the following page with more regular Multiple Choice questions:**
*On your NCS answer sheet, fill in the circle of the letter choice that best completes the statement or answers the corresponding question.*

**16**. If a rocket requires 10 seconds to accelerate from zero to 360 km per hour, its average acceleration is, most nearly,

a. 10 m/ sec$^2$
b. $10^4$ m/ sec$^2$
c. $10^5$ m/sec$^2$
d. $10^7$ m/ sec$^2$
e. $10^9$m/sec$^2$
f. None of the above is within a factor of 3 of the correct acceleration.

$a = \frac{\Delta v}{\Delta t} = \frac{360\,km}{hr \cdot 10\,sec} = \frac{360 \times 10^3\,m}{3600 \cdot (10)\,sec^2} = 10\ m/sec^2$

**17**. A ball is thrown straight up into the air with an unspecified velocity and falls back towards earth. If we do *not* ignore air resistance, the acceleration of the ball as it is traveling downward has a magnitude

a. equal to 9.8 m/s$^2$.
b. greater than 9.8 m/s$^2$.
c. less than 9.8 m/s$^2$, because $F_{drag}$ opposes $F_{Gravity}$
d. zero
e. None of the above, because the acceleration depends upon the velocity.

**18**. A car traveling westward at 36 m/s turns around and travels eastward at 4 m/s. If this takes place in 8 s, what is the magnitude of the average acceleration of the car?

a. 1 m/s$^2$
b. 2 m/s$^2$
c. 3 m/s$^2$
d. 4 m/s$^2$
e. 5 m/s$^2$
f. None of the above is correct within 10%.

$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{+4 - (-36)}{8} = 5\ m/sec^2$

taking EAST as + / directions WEST as −

**19**. A baseball is hit with a speed of 40 m/s at an angle 30° upward. How far has the ball traveled horizontally when it reaches its highest point, most nearly?

a. 30 m
b. 50 m
c. 70 m
d. 90 m
e. 110 m
f. None of the above is within 10% of the correct answer.

$\vec{v}_0 = 40$, 30°

$v_{0y} = 40 \sin 30° = 40 \cdot \frac{1}{2} = 20\ m/sec$

$v_{0x} = 40 \cos 30° = 40\left(\frac{\sqrt{3}}{2}\right) = 34.6\ m/sec$

Ball rises for $\frac{v_{0y}}{g} = 2\,sec$ & travels $2 \cdot (34.6) = 69.2\ m \approx 70$ horizontally in that th

**20**. You want to launch a rocket vertically so that it will reach the altitude of a light plane ~~1000~~ 500 m above the earth's surface. What is the minimum launch speed you can use, most nearly?

a. 1 m/s
b. 10 m/s
c. $10^2$ m/s
d. $10^3$ m/s
e $10^4$ m/s
f. None of the above is correct within 10%

If $g = 10$ = constant rocket falls, starting from rest, $500\ m = \frac{1}{2} g t^2$ in $t = \sqrt{\frac{2 \cdot 500}{10}}\ sec = 10\ sec$

& hits earth with speed $v(t) = v_0 + gt = 100\ m/sec$ (C)

**21.** If an object moves in a straight line with a constant speed, we can conclude that

a. the object has inertia. F: Not unless we can measure $m=F/a$ can we so state.
b. there are no forces acting on the object. F
c. there must be at least two forces acting on the object. F
d. there can be no more than two forces acting on the object. F
e. The vector sum of all the forces acting on it is zero T
f. None of the above completions yields a true statement.. F

**22.** A subway train is moving with constant velocity along a level section of track. The net force on the first subway car is _____ the net force on the last subway car.

a. Finite, but equal and opposite to
b. much greater than
c. slightly greater than
d. less than
e. equal to Because the net force is zero on any & all objects moving with constant velocity
f. None of the above.

**23.** A ball with a weight of 20 N is thrown vertically upward. What is the acceleration of the ball just as it reaches the top of its path?

a. zero
b. 10 m/s$^2$ downward $=g$ (= same throughout flight!)
c. 10 m/s$^2$ upward
d. 20 m/s$^2$ downward
e. 20 m/s$^2$ upward
f. None of the above.

**24.** A parachutist reaches terminal speed when

a. her weight goes to zero. F (It Never happens: $W=mg$)
b. the force of air resistance exceeds her weight. F: then she would accelerate UPWARDS
c. the force of air resistance equals her weight. T
d. the force of air resistance equals her mass. F [Dimensionally impossible for Force to equal a Mass]
e. only when she spreads our her limbs to increase the air resistance. F
f. None of the above completions yields a true statement. F

**25.** You must apply a 75-N force to pull a child's wagon across the floor at a constant speed of 0.5 m/s. If you increase your pull to 90 N, the wagon will

a. continue to move at 0.5 m/s.
b. speed up immediately and then move at the faster constant speed of 0.6 m/s.
c. speed up gradually until it reaches the speed of 0.6 m/s and then move at that constant speed.
d. continue to speed up as long as you keep pulling, Since Net Force is positive & so is acceleration
e. do none of the above.

**26.** A book sits at rest on a table. Which force does Newton's third law tell us is equal and opposite to the gravitational force acting on the book?

a. the normal force exerted by the table on the book F
b. the normal force exerted by the book on the table F
c. the gravitational force exerted by the book on the Earth T
d. the net force on the book F
e. All of the above forces are NIII pairs with the gravitational force on the book F
f. None of the above . F

**27.** A migrating bird is initially flying south at 12 m/s. To avoid hitting a high-rise building, the bird veers and changes its velocity to 16 m/s east over a period of 5 s. What is the magnitude of the bird's average acceleration during this 5-s interval?

a. 1 m/s$^2$
b. 3 m/s$^2$
c. 4 m/s$^2$
d. 5 m/s$^2$
e. None of the above is within 10% of the correct answer.

$v_i = 12$ S; $v_f - v_i$; $v_f = 16$ E

$|\vec{a}|_{Ave} = \frac{|\vec{v}_f - \vec{v}_i|}{\Delta t} = \frac{\sqrt{(16)^2+(12)^2}}{5} = \frac{20}{5} = 4\ m/sec^2$

**28.** A red ball is thrown straight down from the edge of a tall cliff with a speed of 50 m/s. At the same time a green ball is thrown straight up with the same speed. If the green ball travels up, stops, and then drops to the bottom of the cliff, how many seconds later than the red ball does the green ball arrive at the bottom of the cliff?

a. 2 second
b. 4 seconds
c. 6 seconds
d. 8 seconds
e. 10 seconds
f. Because the height of the cliff is unspecified, there is not enough information to say.
g. There is a well defined correct answer, none of the above choices, a) through e) is within 10%.

GREEN Ball rises for $v_{y_f} = \frac{50}{10} = 5$ sec, then begins to fall. 5 seconds later it is just when RED ball started at $y = 0$ with $v_y = -50$ m/sec. In all GREEN is delayed by 5+5 = 10 sec

**Scenario 29**

A gun is held horizontally and fired. At the same time the bullet leaves the gun's barrel an identical bullet is dropped from the same height. Neglect air resistance.

**29.** Refer to **Scenario 29** above. Which bullet will hit the ground with the greatest velocity?

a. The bullet that was fired, because it feels the force of gravity over a longer distance.
b. The bullet that was dropped, because it falls for a longer time
c. It will be a tie, because the acceleration of gravity is the same for both.
d. The bullet that was fired. ← because $|\vec{v}_f| = \sqrt{v_y^2 + v_x^2}$ has both a vertical AND a non zero horizontal component for fired bullet.
e. The bullet that was dropped.
f. It is not possible to say with the information given.

**30.** You are applying a 400-newton force to a freezer full of chocolate chip ice cream in an attempt to move it across the basement, but it will not budge. The weight of the freezer (including ice cream) is 1000 N, and $\mu = 0.70$ is the coefficient of static friction.. The frictional force exerted by the floor on the freezer as the force is applied is

a. 400 N
b. greater than 700 N but less than 1000 N
c. greater than 400 N but less than 700 N
d. 700 N
e. 1000 N.
f. None of the above completions ( a through e) yields a correct statement.

$F_{fr} = F_{Applied}$, if only $F_{fr} < F_{fr}^{MAX} = (1000)(.7) = 700\,N$

Thus $F_{Applied} = 400\,N \Rightarrow F_{fr} = 400\,N$

**31.** A ball with a weight of 30 N is thrown vertically upward. What are the size and direction of the force on the ball just as it reaches the top of its path?

a. zero
b. 10 N upward
c. 10 N downward
d. 30 N downward
e. 30 N upward
f. At the top of the trajectory the force on the ball is actually horizontal
g. None of the above.

$F = F_g = \text{constant} = W = mg = 30\,N$ downward

**32.** You leap from a bridge with a bungee cord tied around your ankles. As you approach the river below, the bungee cord begins to stretch and you begin to slow down. The force of the cord on your ankles to slow you is _____ your weight _____.

a. less than.....and increasing
b. equal to.....exactly
c. greater than.....and decreasing
d. less than.....and decreasing
e. greater than.....and increasing
f. None of the above statements is true.

a) MUST be greater than weight to slow you down
b) " be increasing because Hooke's Law force increases with increasing extension of the spring.

**33.** A car initially traveling westward at 16 m/s has a constant acceleration of 2 m/s$^2$ eastward. How far has the car traveled after 16 s?

a. 768 m
b. 512 m
c. 256 m
d. 0 m
e. None of the above is within 10% of the correct answer.

$x - x_0 = +v_{0x}t + \frac{1}{2}a_x t^2$ & take W EST to be + / EAST IS −

$D = +16(t) - \frac{1}{2}\cdot 2t^2 = (16)(16) - (16)^2 = 0$

**34.** What is the acceleration due to earth's gravity at a distance of 100 earth radii from the earth's center?

a. 10 m/s$^2$
b. 1 m/s$^2$
c. $10^{-1}$ m/s$^2$
d. $10^{-2}$ m/s$^2$
e. $10^{-3}$ m/s$^2$
f. None of the above is within 10% of the correct acceleration.

at $D = 1R_E$ accln is $g = 10\,m/sec^2$

at $D = 100R_E$ accln is $\frac{1}{(100)^2}$ smaller $= \frac{g}{10^4} = 10^{-3}\,m/sec^2$

**35.** Suppose that a certain planet, P, has a radius of about 4.0 earth radii and a mass equal to 8.0 earth masses. Estimate the acceleration due to gravity on the surface of planet, P.

a. 80 m/s$^2$
b. 40 m/s$^2$
c. 20 m/s$^2$
d. 10 m/s$^2$
e. 5 m/s$^2$
f. None of the above is within 10% of the correct answer.

$g = G\frac{M_E}{R_E^2}$ near Earths surface

$g = G\frac{M_P}{(R_P)^2} = G\frac{8M_E}{(4R_E)^2} = \frac{8}{16}G\frac{M_E}{R_E^2} = \frac{1}{2}g = 5\ m/sec^2$

**36.** Two objects have different masses but the same kinetic energies. If you stop them with the same constant retarding force, which one will stop in the shorter distance?

a. the heavier one, because it has a larger inertia.
b. the lighter one, because it has less momentum.
c. the lighter one, because it requires less impulse to stop
d. both stop in the same distance, because of the work energy theorem.
e. both stop in the same distance because of the impulse/momentum theorem
f. None of the above is completely true.

$F\cdot\Delta x = W = \Delta(KE)$ WORK-ENERGY

$\Delta x = \frac{\Delta(KE)}{F}$ IS SAME for both

**37.** Two objects have different masses but the same momenta. If you stop them with the same constant retarding force, which one will stop in the shorter distance?

a. the heavier one, because it is moving slower than the lighter one
b. the lighter one, because it will stop in a shorter time
c. both stop in the same distance because of the impulse/momentum theorem.
d. both stop in the same distance, because of the work energy theorem.
e. None of the above is completely true.

Impulse/Momentum

$F\cdot\Delta t = \Delta p$

$\Rightarrow \Delta t = \frac{F}{\Delta p}$ is same for both

& heavier travels shorter distance in $\Delta t$

**38.** A tennis ball on the end of a string travels in a horizontal circle at a constant speed. The circle has a circumference of 3 m, the ball has a speed of 2 m/s, and the centripetal force is 1.5 N. How much work is done on the ball each time it goes around?

a. zero
b. 2 J
c. 3.0J J
d. 4.5 J
e. 6 J
f. 9π J
g. None of the above is within 10% of the correct answer.

because $\vec{F} \perp \vec{\Delta x}$

**39.** A 1-kg ball falling freely through a distance of one meter loses 10 J of gravitational potential energy. How much does the kinetic energy of the ball change if this occurs in a vacuum?

a. gain of 10 J
b. gain of 1 J
c. loss of 10 J
d. loss of 1 J
e. the kinetic energy gain is zero
f. None of the above

by CONS of ME = KE + PE for CONSERVATIVE GRAVITY force.

**40.** Under what conditions is the kinetic energy (KE) conserved (in the strict sense of the word) during a collision?

a. KE is always conserved.
b. KE is conserved when the collision is totally elastic.
c. KE is conserved when there is no net outside force.
d. KE is conserved when there is no friction.
e. KE is never strictly conserved during a collision. because it does NOT remain constant throughout collision
f. None of the above answers is correct.

**41.** The numerical value of G, the gravitational constant, was first determined

a. from the earth's volume and a guess about its average mass density.
b. from the law of universal gravitation and the value of the acceleration due to gravity.
c. from the value of the moon's acceleration.
d. by measuring the force between masses in the laboratory. CAVENDISH'
e. from a very precise knowledge of the mass of the earth.
f. None of the above methods was used to determine G.

**42.** The general form of the force of universal gravitation is $F = GMm/r^2$, but we used the simpler form, $F = mg$, when we studied projectile motion. Which of the following arguments validates this?

a. The first form is not valid for projectile motion. F
b. The first form does not work because it requires two masses. F
c. The first form is not valid near the surface of the earth. F
d. The simpler form is easier to calculate and therefore preferable to the first. INSUFFICIENT
e. The first form reduces to the second when r is nearly equal to the radius of the earth. T
f. None of the above is a valid and sufficient reason for using the second form. F

**43.** A 300-kg satellite experiences a gravitational force of 1500 N. What is the height of the satellite's orbit above the earth's surface, most nearly? (in units of $R_E$ = Earth's Radius)

a. 0.4 $R_E$
b. 0.7 $R_E$
c. 1.4 $R_E$
d. 1.7 $R_E$
e. 2.0 $R_E$
f. 3.0 $R_E$
g. None of the above is within 10 % of the correct height.

$300\,\tilde{g} = 1500\,N \Rightarrow \tilde{g} = 5\,m/sec^2 = g/2$

Then $(R_E + h)^2 = 2R_E^2$

$\cancel{(R_E)^2}(1 + h/R_E)^2 = 2\cancel{R_E^2} \Rightarrow 1 + h/R_E = \sqrt{2} = 1.414$

$h/R_E = (1.414 - 1)$

$h = 0.414\,R_E$ (a)

**44.** You have a mass of 70 kg. How fast would you have to run to have the same momentum as a truck ($M$ = 25,200 kg) rolling along at 1 km per hour?

a. $10^6$ m/s
b. $10^4$ m/s
c. $10^2$ m/s
d. 10 m/s
e. 1.0 m/s
f. $10^{-1}$ m/s.
g. None of the above is within 10% of the correct answer.

$P_T = M v_T = \frac{1 \times 10^3}{hr} M_T = \frac{(1 \times 10^3)}{\cancel{hr}}(25{,}200)\,kg\,m \frac{1\,\cancel{hr}}{3600\,sec} = 7000\,\frac{kg\,m}{sec}$

$= mv = 70v$

$v = \frac{7000}{70} = 100\,m/sec.$

**45.** Air bags are used by stunt people when they fall off buildings to reduce the _____ that occurs during the collision.

a. change in momentum
b. work
c. impulse
d. change in velocity
e. force
f. kinetic energy
g. None of the above.

**46.** A very hard rubber ball ($m = 0.5$ kg) is falling vertically at 4 m/s just before it bounces off the floor. The ball rebounds back at essentially the same speed. If the collision with the floor lasts 0.01 s, what is the average force exerted by the floor on the ball during the bounce?

a. 40 N
b. 100 N
c. 200 N
d. 400 N
e. None of the above is within 10% of the correct answer.

$\bar{F}\Delta t = \Delta p$ ⇐ Impulse/momentum Thm.

$\bar{F} = \frac{\Delta p}{\Delta t} = \frac{mv - (-mv)}{\Delta t} = \frac{2\cdot(0.5)(4)\,m/sec}{10^{-2}\,sec} = 4\times10^{2}\ N$

**47.** When a star undergoes a supernova explosion, the total linear momentum of the star

a. increases suddenly
b. increases in the outward direction
c. decreases rapidly at first and then more slowly as the star expands.
d. decreases at a nearly uniform rate once the explosion has occurred.
e. remains constant since star is an isolated system & momentum is conserved.
f. There is not enough information to say.
g. None of the above is correct.

**48.** A 60-kg frictionless roller coaster starts from rest at a height of 20 m. What is its kinetic energy when it goes over the top of a hill that is 15 m high?

a. 300 J
b. 900 J
c. 1,200 J
d. 3,000 J
e. 9,000 J
f. 12,000
g. None of the above answers is within 10% of the correct result.

Conserve:

$(PE) + (KE) = \text{const} = 60\cdot(20)\cdot(10) + 0 = (PE)_i + (KE)_i$

$= (PE)_f + (KE)_f = 60\cdot15\cdot10 + KE_F$

i.e. $(KE)_f = (60\cdot10)(20-15) = 3000\ J$

**49.** How much energy is required to light a 30-W bulb for 8 h? (1 W = 1 Joule/sec)

a. $8.6 \times 10^5$ J
b. $2.4 \times 10^4$ J
c. $8.6 \times 10^3$ J
d. $2.4 \times 10^2$ J
e. None of the above answers is within 10% of the correct result.

$30\,\frac{J}{sec} \times 8\,hr \times \frac{3600\,sec}{1\,hr} = 8.64\times10^5\ J$

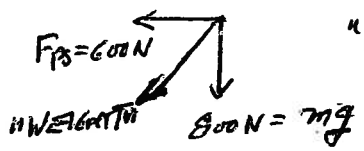
**50.** A ball is thrown horizontally at 30 m/s from a flatcar that is moving in a straight line at 40 m/s. Relative to a person on the ground, what is the horizontal speed of the ball when it is thrown directly towards the front of the flatcar?

a. 10 m/s
b. 30 m/s
c. 40 m/s
d. 50 m/s
e. 70 m/s
f. None of the above.

$v' = v + V = +30 + 40 = +70$ m/sec

**51.** A person who weighs 800 N when at rest is riding in the rotating cylinder ride. The cylinder rotates fast enough to create an 600-N centrifugal pseudo-force outward in the horizontal direction. What is the magnitude of the person's "weight" (i.e.,the combination of the gravity force and the inertial pseudo-force) in the rotating reference frame, most nearly?

a. 600 N
b. 800 N
c. 1000 N
d. 1200 N
e. 1400 N
f. 1600 N
g. None of the above answers is within 10% of the correct result.




"WEIGHT" $= \sqrt{(800)^2 + (600)^2}$
$= \sqrt{64 + 36} \times 100$
$= 1000$ N

**52.** If Newton had attempted to launch his apple horizontally in order to make it travel in a circle around the earth, what horizontal speed would it have to have to stay at the same small height above the earth's (presumed smooth for the present discussion) surface? (Take the radius of the earth to be $6.4 \times 10^6$ m)

a. $6 \times 10^6$ m/s
b. $8 \times 10^5$ m/s
c. $6 \times 10^4$ m/s
d. $8 \times 10^3$ m/s
e. $6 \times 10^2$ m/s
f. None of the above is within 10% of the correct answer.

$\frac{v_H^2}{R_E} = g \Rightarrow v_H = \sqrt{(g R_E)} = \sqrt{(6.4 \times 10^6) 10}$
$v_H = \sqrt{64 \times 10^6} = 8 \times 10^3$ m/sec

**53.** A 120-kg satellite orbits a distant planet with a radius of 4000 km and a period of 4.94 hours. From the radius and period, you calculate the satellite's acceleration to be 0.005 m/s$^2$. What is the gravitational force on the satellite, most nearly?

a. 0.6 N
b. 6 N
c. 60 N
d. 600 N
e. 1200 N
f. None of the above is within 10% of the correct value.

$F = ma = (120)(5 \times 10^{-3}) = 600 \times 10^{-3} = 0.60$ N

**54.** According to the special theory of relativity, all laws of nature are the same in reference systems which _____ relative to an inertial system.

a. rotate at a fixed angular velocity F
b. have a constant acceleration F
c. move at a constant velocity T
d. move in ellipses F
e. move in circles at a constant speed F
f. None of the above F

**55.** In his theory of special relativity, Einstein

a. abandoned the Galilean principle of relativity. F
b. abandoned Maxwell's equations for electricity and magnetism F
c. reconciled the apparent conflict between the Galilean principle of relativity and Maxwell's equations. F: NO CONFLICT EXISTED
d. postulated the existence of an absolute reference system. F
e. postulated that the speed of light is constant in vacuum, and the same in all inertial frames. T
f. All of the above completions yield true statements. F
g. None of the above. F

**56.** The second postulate of special relativity does NOT require that the speed of light

a. is a constant in a vacuum and equal to c. F
b. is independent of the motion of the receiver. F
c. is independent of the motion of the source. F
d. is independent of the direction of propagation F
e. In fact, the second postulate requires all of the above statements, a through d. T
f. In fact, the second postulate requires none of the statements a through d. F

**57.** As a friend passed you at a very high speed, she reported, she simultaneously exploded a firecracker at each end of her skateboard. Which one exploded first from your point of view?

a. the one at the front
b. the one at the back Because you see its flash earlier than she.
c. They exploded simultaneously.
d. The answer depends on the speed of the skateboard.
e. None of the above is a correct answer to the question.

**58.** Superman wants to travel back to his native Krypton for a visit, a distance of $3X10^{15}$ meters. (At nearly the speed of light, it takes light nearly $10^7$ seconds to travel this distance.) If Superman is able to hold his breath for $10^3$ s and travel at any speed less than that of light, can he make it before he suffocates?

a. No way. F
b. Yes, but only if he goes faster than light. F
c. Not unless he is able to take a breath along the way. F
d. Yes, because in his frame his biological clock slows down to give him more time F
e. Yes, because in his frame of reference the distance he needs to travel is contracted to a much smaller value. T
f. None of the above comments is true and relevant to the question F

**59.** In the twin paradox one twin remains on earth while the other makes a trip to a distant location and back at the same constant speed, close to the speed of light, c. Each twin argues that at the end of the round trip his brother will have aged less than he. When the twins are reunited on earth, which of their claims will prove to be valid? The valid claim is that of

a. the twin who remained on earth, because he did not undergo any acceleration. T
b. the twin who made the trip, because he had to accelerate to turn around. F : Accln alters clocks.
c. Actually, both are mistaken: they are the same age, because the speed was held constant out and back. F
d. The answer depends upon the details of the turnaround. F
e. None of the above statements is true. F

**60.** If you approach a light beacon while traveling at a speed of seven tenths the speed of light (0.7c), you will measure the speed of light from the beacon to be

a. 0.3c
b. 0.7c
c. c
d. 1.3c
e. 1.7c
f. None of the above is within 10% of the correct answer.

**61** A ham sandwich consists of one slice of ham (5 g) and two slices of bread (10 g each). You have 1 kg of ham and 2 kg of bread. You make as many sandwiches as you can. What is the mass of the sandwiches you can make, most nearly?

a. 0.75 kg
b. 1.00 kg
c. 1.25 kg
d. 2.00 kg
e. 2.50 kg
f. 3.00 kg
g. None of the above is within 10% of the correct answer.

Since Mass of bread in sandwich is 4x mass of HAM
2 kg of bread makes fewer sandwiches than 1 kg HAM.
Then bread will run out after $\frac{2\times10^3}{2\times10}$ = 100 sandwiches (2.5 kg).
& 500 gm of HAM is left over.

**62.** Joule's experiments with hanging weights turning paddle wheels in water

a. showed that the same amount of work always generated the same amount of heat. T
b. showed that heat was not a fluid. F
c. were used to define the calorie. F
d. showed that heat could be converted 100% to mechanical energy. F
e. All of the above. F
f. None of the above. F

**63.** Which of the following is NOT assumed in our model of the ideal gas? The gas molecules

a. rebound elastically when they collide with the container wall. Assumed
b. have no internal structure. "
c. are indestructible. "
d. do not interact except when they collide. "
e. sometimes break up into their separate atoms NOT ASSUMED
f. Each of the properties a) through e) above is an assumed characteristic of our ideal gas; i.e., none of them is NOT assumed.) F

**64.** The first law of thermodynamics

a. is a restatement of the law of conservation of energy which includes heat as energy. T
b. allows that internal energy can be completely converted into work. T
c. includes kinetic and potential energy at the atomic/molecular level in its internal energy. T
d. guarantees that the work extracted by a *cyclic* heat engine can never be less than the net heat input. T
e. All of the statements a) through d) above are true of the first law. T
f. None of the statements a) through d) above are true of the first law. F

**65.** A hypothetical balloon filled with an ideal gas has a volume of $10^5$ liters at 27°C under one atmosphere of pressure. At what temperature, most nearly, would its volume be $10^4$ liters under one atmosphere of pressure (assuming that as the temperature changes it continues to behave as an ideal gas)?

a. 0.27°C
b. -0.27°C
c. - 27°C
d. -243°C
e. -270°C
f. -273°C

Divide both sides: $\frac{P_i V_i}{P_f V_f} = \frac{\cancel{k} T_i}{\cancel{k} T_f} \Rightarrow T_f = \left(T_i\right)\left(\frac{P_f}{P_i}\right)\left(\frac{V_f}{V_i}\right)$

$27°C = T_A = 273 + 27 = 300\,K$

$= 300\,K \cdot \left(\frac{1}{1}\right) \cdot \frac{10^4}{10^5}$

$= 30\,K = T_C + 273$

$T_C = -273 + 30 = -243°C$

**66.** Two objects are in thermal equilibrium if

a. they have the same temperature. T
b. they are each in thermal equilibrium with the same third object. T
c. they are in thermal contact and there is no net flow of thermal energy. T
d. Their total entropy would not increase if heat energy were transferred between them T
e. All of the statements a) through d) above are true. T
f. None of the statements a) through d) above is true. F

**67.** In hot weather near a coast the sunlight heats the land surface more rapidly than the water surface, causing the air over the land to rise and be replaced by air flowing in from the water (a "sea breeze" driven by convection). A key element in this process is the fact that

a. water has a higher specific heat than rock and soil. T
b. water has a higher latent heat of vaporization than rock or soil F
c. the coasts have lower elevations, and cool air tends to flow downhill. F
d. it rains a lot on the coasts. F
e. Because breezes always blow from sea to land. F
f. None of the above: coastal climates are not, in fact, more moderate than inland climates.

**68.** Aluminum and air have almost the same value (0.2cal/gm-deg C) for their specific heats. Therefore, 100 calories of heat will raise the temperature of 1 liter of aluminum _____ 1 liter of air. (Assume T = 20°C, and P = 1 atm.)

a. much more than
b. slightly more than
c. about the same as
d. slightly less than
e. much less than because 1 l of Al has a much larger mass than 1 l of air
f. There is not enough information to justify a statement.

**69.** Thirty two liters of an ideal gas are cooled from 1200 K to 300 K while the pressure is maintained at 1 atm. What is the final volume of the gas, most nearly?

a. 16 liters
b. 8 liters
c. 4 liters
d. 2 liters
e. 1 liter
f. None of the above is within 10% of the correct answer.

$\frac{P_f V_f}{P_i V_i} = \frac{\cancel{P} T_f}{\cancel{P} T_i} = \frac{300}{1200} = \left(\frac{1}{4}\right) \cdot \frac{V_f}{V_i} \Rightarrow V_f = V_i \cdot \frac{3}{12} = \frac{32}{4} = 8$

**70.** What would happen to a pot of water at on a hot (T>100° C) stove if the latent heat of vaporization required to convert water to steam were equal to 1 cal/gm instead of the actual value of 540 cal/gm?

a. The water would not boil. F
b. The water would boil at a higher temperature. F
c. The water would all turn to steam very rapidly. T
d. The water would not form steam. F
e. None of the above. F

**71.** The boiling point of liquid nitrogen at atmospheric pressure is 77 K. Which of the following absolute temperatures is the closest to the temperature of liquid nitrogen in an open container setting in a laboratory where the room temperature is 27°C ?

a. 76 K
b. 77 K
c. 78 K
d. 196 K
e. 300 K
f. None of the above is within 10% of the correct answer.

TEMP is constant until all Nitrogen is converted to gas.

**72.** Given that 1 g of hydrogen combines completely with 8 g of oxygen to form water, how many grams of water can you make with 8 g of hydrogen and 32 g of oxygen?

a. 4 g
b. 8 g
c. 9 g
d. 32 g
e. 40 g
f. None of the above is within 10% of the correct answer.

32g O combines with 4gm H to make 36g $H_2O$

**73.** If you double the absolute temperature of an ideal gas and triple its pressure, what happens to its volume? The volume changes by a factor of, most nearly,

a. 6
b. 3
c. 1.5
d. 1.0
e. 0.67
f. 0.33
g. 0.17

$\frac{V_f P_f}{V_i P_i} = \frac{\cancel{P} T_f}{\cancel{P} T_i} \Rightarrow \frac{V_f}{V_i} = \frac{T_f}{T_i} \times \frac{P_i}{P_f} = \frac{(2)}{3} = 0.67$

**74.** A steel rail is 5.56 km long. How much does its length change during a day when the low temperature is 50° F (18° C) and the high temperature is 91° F (33° C)? Steel has a coefficient of thermal expansion, $\alpha = 1.2 \times 10^{-5}$ /°C.

a. 0.01 cm
b. 0.1 cm
c. 1.0 cm
d. 10.0 cm
e. 100.0 cm
f. None of the above answers is withing 10% of the correct value.

$\Delta L = \alpha \cdot L \cdot \Delta T = (1.2\times10^{-5})(5.6\times10^{3})(33-18)$
$= 100\times10^{-2} = 1\ m = 100\ cm$ (e)

**75.** If a liter of gas has a pressure of 2.0 atmospheres, what will the pressure be if the average kinetic energy of the molecules is cut in half while the volume is quadrupled ?

a. 0.5 atm
b. 1 atm
c. 2 atm
d. 4 atm
e. 8 atm.
f. 16 atm.
g. None of the above is within 10% of the correct answer.

This is the corrected solution

$(KE)_{AVE} = \frac{3}{2}kT \Rightarrow$ HALVING KE $\Rightarrow$ HALVING T.

$\frac{P_f V_f = \cancel{k} T_f}{P_i V_i = \cancel{k} T_i} \Rightarrow P_f = P_i\left(\frac{V_i}{V_f}\right)\left(\frac{T_f}{T_i}\right) = (2)\cdot\frac{1}{4}\ \frac{1}{2} = \frac{1}{4}$ Atm.

(g) No answer a-f is within 10%

**76.** One liter of an ideal gas is heated from 280 °C to 2492 °C while the pressure is maintained at 1 atm. What is the final volume of the gas, most nearly?

a. 1 liters
b. 2 liters
c. 3 liters
d. 4 liters
e. 5 liters
f. None of the above is within 10% of the correct answer

$\frac{\cancel{P_f} V_f = \cancel{k} T_f}{\cancel{P_i} V_i = \cancel{k} T_i} \Rightarrow V_f = \frac{(2492+273)}{(280+273)}\cdot(1\ l) = 5\ l$

**77.** It is NOT possible to convert completely

a. heat into internal energy. F
b. mechanical energy into internal energy. F
c. potential energy into mechanical work. F
d. work into heat. F
e. Internal energy into work T
f. All of the above transformations are in fact possible. F

**78.** The second law of thermodynamics requires

a. that a refrigerator can operate only it work is supplied. T
b. that it is impossible to build a heat engine which extracts mechanical work from heat energy that does not also exhaust heat to the surroundings. T
c. that it is impossible to run a heat engine entirely on heat from its own exhaust. T
d. that in each cycle of a heat engine the total entropy of the engine and its surroundings increases. T
e. That to make ice cubes out of sea water work must be consumed. T
f. All of the above (a through d) are required by the second law. T

**79.** A heat engine

a. converts thermal energy into mechanical energy. T
b. converts mechanical energy into thermal energy. F
c. violates the first law of thermodynamics. F
d. can as a matter of principle always be made more efficient. F
e. All of the above completions(a through d) yield true statements. F
f. None of the above completions(a through d) yields a true statement. F

**80.** The second law of thermodynamics

a. says that it is impossible to reach the absolute zero of temperature. F
b. says that the total entropy of an isolated system tends to increase. T
c. is the basis for the definition of temperature. F
d. is the basis for the definition of internal energy. F
f. is simply the law of conservation of energy with heat included as a form of energy. F
g. None of the above completions yields a true statement. F

**81.** Which of the following statements contradicts the second law of thermodynamics?

a. Heat naturally flows from hot objects to cold objects. NO CONTRAD.
b. No engine can transform all of its heat input into mechanical work. " "
c. The entropy of an isolated system can never decrease. NO CONTRAD
d. Perpetual motion machines are ~~possible~~, but difficult. CONTRADICTS
e. Refrigerators cannot run without work being done on them NO CONTRADICTION
f. All of the above conform to the second law of thermodynamics, and none contradicts it. F

**82.** How many different outcomes are there from the flipping of five different coins, and what fraction of those yields the most ordered result (i.e., all heads or all tails), respectively?

a. 4 and 50%, respectively.
b. 8 and 25%, respectively.
c. 16 and 12.5%, respectively.
d. 32 and 6.25%, respectively.
e. None of the above are correct within ± 1%.

$(2)^5 = 32$ $\quad \frac{2}{32} = \frac{1}{16} = 6.25\%$

**83.** An engineer has designed a machine to produce electricity by using the difference in the temperature of ocean water at depths of 0 and 50 m. If the surface temperature is 27° C and the temperature at 50 m below the surface is 7° C, what is the maximum work this machine can extract per joule of heat put in at the surface, most nearly?

a. 0.01 J
b. 0.03 J
c. 0.05 J
d. 0.07 J
e. 0.14 J
f. None of the above is within ±10% of the correct answer.

$\eta_{MAX} = \eta_{CARNOT} = \frac{W}{Q_{IN}} = \left(1 - T_C/T_H\right) = \left(1 - \frac{280}{300}\right) = \left(\frac{20}{300}\right) \approx 0.07$

$W^{MAX} = 0.07\,(Q_{IN}) = 0.07\,J$ for each J of Heat in

**84.** A hot piece of metal is dropped into an insulated container of cold water. After the system has reached its equilibrium temperature, the

a. entropy of the metal has decreased. T
b. entropy of the water has increased. T
c. net change in entropy of the system is positive. T
d. final temperature of the system lies between the initial temperatures of the metal and the initial temperature of the water. T
e. All of the statements a) through d) above are true.
f. None of the statements a) through d) above is true F

**85.** The efficiency of an ideal heat engine can be improved by _____ the input temperature and _____ the exhaust temperature.

a. increasing ... increasing
b. increasing ... decreasing
c. decreasing ... increasing
d. decreasing ... decreasing
e. None of the above: the efficiency of the ideal heat engine is independent of actual temperature, and depends only on the absolute temperature.

$\eta_{CARNOT} = \left(1 - \frac{T_{EX}}{T_{INPUT}}\right) = \left(1 - T_C/T_H\right)$

**86.** A heat engine takes in energy at a rate of 4800 W at 800 K and exhausts heat at a rate of 1200 W at 400 K. What is the actual efficiency of this engine?

a. 25%
b. 40%
c. 50%
d. 75%
e. None of the above is within 10% of the correct efficiency.

$\eta = \frac{W^{OUT}}{Q^{IN}} = \frac{4800 - 1200}{4800} = \frac{3}{4} = 75\%$

**87.** An ideal Carnot heat engine has a theoretical efficiency of 40% and an exhaust temperature of 227° C. What is its input temperature, most nearly ?

a. 380° C
b. 560° C
c. 830° C
d. 1000° C
e. 1250° C
f. None of the above is within 10% of the correct answer

$\eta_{CARNOT} = 0.40 = \left(1 - T_C/T_H\right) \Rightarrow \frac{T_C}{T_H} = 0.60$

$T_H = T_C/0.60 = 500/0.60 = 833K$

[Since $T_C = (227+273)K = 500K$]

& $833 - 273 = T_C = 560°C$

**88.** An air-conditioner mechanic is testing a unit by running it on the workbench in an isolated room. The unit removes 100 cal/min from the refrigerated chamber, utilizing a work input of 220 J/min. By how much does the internal energy of the room outside the refrigerated chamber change, most nearly, in each minute? (Recall that 4.2 J = 1 cal.)

a. It decreases by 100 cal/min.
b It decreases by 220 cal/min
c. It decreases by 320 cal/min.
d. It stays the same.
e. It increases by 320 cal/min
f. It increases by 220 cal/min.
g. It increases by 100 cal /min
h. None of the above is within 10% of the correct answer.

**89.** The periodic table arranges the elements in columns according to

a. the order in which they were discovered.
b. their chemical properties.
c. their relative abundances.
d. alphabetical order.
e. their atomic masses
f. None of the above.

**90.** Which is a correct observation of what happened in our cathode ray tube demonstrations?

a. The end of the glass tube opposite the cathode glows.
b. A metal cross casts a shadow, indicating the rays travel in straight lines.
c. The particles are seen only when an accelerating voltage is applied
d. The stream of particles is deflected by an magnetic field.
e. All of the above.

**91.** According to classical theory an atom like that of the Rutherford model should be unstable because the electrons would spiral inward and collapse into the nucleus' volume very rapidly. What was expected to cause this instability in Rutherford's model?

a. The positive charge in the nucleus was too far from the electrons to hold them in orbit.
b. The attractive force between the positive nucleus and the electrons would pull them together.
c. The centripetal acceleration for the circular motion required too large a force.
d. An accelerating charge was known to radiate energy.
e. Nature abhors a vacuum.
f None of the above.

**92.** When light is incident on a metallic surface, the emitted electrons

a. are called photons.
b. have arbitrarily high energies.
c. have a maximum energy that increases with the intensity of the light.
d. Are referred to as cathode rays.
e. Become more numerous as the frequency increases.
f. None of the above

**93.** Two hydrogen atoms have electrons that jump from the n = 3 (third highest)energy level to the n = 1 (lowest) energy level. One jumps directly to the n = 1 level emitting one photon, while the other jumps to the n = 2 level first and then to the n = 1 level, emitting two photons. The total energy of the pair of emitted photons _____ that of the single emitted photon.

a. is much greater than
b. Is slightly greater than
c. is exactly the same as  By conservation of energy
d. is slightly less than
e is much less than
f. cannot readily be compared with
g. None of the above is relevant because frequencies determine energies for photons.

**94.** Einstein was able to account for the experimental observations of the photoelectric effect by assuming that

a. the metal contained atomic resonators.
b. light is a wave phenomenon.
c. light consists of particle-like wave packets, photons, each with energy e = hf .
d. electrons boil off when they get hot enough.
e The intensity of the electromagnetic field was the determinant of the electrons' energies.
f. None of the above.

**95.** What is the frequency of the minute hand on a clock, most nearly?

a. 3600 Hz  $f = 1\,\text{cycle/hour} \times 1\,\text{hr}/3600\,\text{sec} = \frac{1}{3600\,\text{sec}} = 2.8\times10^{-4}\,\text{Hz}$
b. 60 Hz  $\approx 3\times10^{-4}\,\text{Hz}$ (e)
c. 1 Hz
d. $2 \times 10^{-2}$ Hz
e. $3 \times 10^{-4}$ Hz
f. None of the above is within a factor of 2 of the correct frequency.

**96.** Which of the following sets of parameters all affect the period of a pendulum? (M = Mass, L = Length, and g = acceleration due to gravity)

a. (M, L and g)
b. (M and L)
c. (M and g)
d. (L and g)
e. L only
f. None of the above.

**97.** For small amplitudes the period of a pendulum is _____ the acceleration due to gravity.

a. proportional to
b. proportional to the square root of
c. inversely proportional to the square root of  $T = 2\pi\sqrt{L/g}$
d. inversely proportional to
e. None of the above.

Check dimensionality : $\left[\frac{L}{g}\right]^{1/2} = \left(\frac{L}{4\pi^2}\right)^{1/2} = (T^2)^{1/2} = T$

all for period

**98.** Which of the following expressions gives the correct relationship between the wavelength, the period or frequency, and the velocity for a periodic wave?

a. $v = \lambda T$
b. $v = \lambda f$ dimension $\frac{L}{T} = \frac{L}{T}$ (ok)
c. $v = \lambda / f$
d. $v = fT$
e. None of the above.

**99.** The ratio of the speed of a periodic sound wave of frequency of 220 Hz to that of a wave with a frequency of 440 Hz is, most nearly:

a. 0.5
b. 0.71
c. 1.0
d 1.41
e. 2.0
f. None of the above is correct within 10%.

**100.** A periodic wave on a string has a wavelength of 30 cm and a frequency of 4 Hz. What is the speed of the wave?

a. 7.5 cm/s
b. 30 cm/s
c. 60 cm/s
d. 120 cm/s
e None of the above is correct within 10%.

**101.** A clean surface of potassium metal will emit electrons when exposed to blue light. If the **intensity** of the blue light is increased, the _____ of the ejected electrons will also increase.

a. maximum kinetic energy F
b. number T
c. mass F
d. average kinetic energy F
e. All of the above quantities increase with intensity. F
f. None of the quantities a) through d) increases with the blue light intensity. F

**102.** A clean surface of metal will emit electrons when exposed to light. If the color of the light is changed from red to blue without changing the intensity, the _____ of the ejected electrons will also increase.

a. mass F
b. number F
c. minimum kinetic energy F (min is always zero)
d. maximum kinetic energy T
e. charge F
f. None of the above will increase with the stated change in color. F

**103.** Which of the following lists photons in order of **increasing** wave length?

a. γ ray < X ray < ultraviolet < visible < infrared < microwave OK
b. infrared > visible > ultraviolet > X ray < radio NO
c. radio > infrared, X ray, visible, ultraviolet NO
d. radio > infrared, visible, ultraviolet, γ ray NO.
e. None of the above meets the ordering criterion stated. F

**104.** Which of the following is NOT a feature of the Bohr model of the atom?

a. a quantized electron angular momentum, rp, for the orbits.
b. electrons in planetary-like orbits, spiraling inward towards the nucleus. ← NOT ALLOWED IN BOHR MODEL
c. discretely quantized energy levels
d. accelerating electrons that do not radiate
e ranges of circular electron orbits which are physically forbidden to electrons.
f. All of the above are features of the Bohr model.

**105.** Which of the following is NOT considered to be a success of Bohr's theory of the atom?

a. Obtaining the numerical values for the spectral lines in hydrogen. ✓
b. Explaining why the same lines occur in the emission spectra as in the absorption spectra. ✓
c. Explaining why the frequency distributions in emission spectra are discrete, not continuous. ✓
d. Providing the general features of the periodic table. ✓
e. Providing a rationale for Bohr's quantum condition, $2\pi rp = nh$. ← NO Rationale was offered
f. All of the above are considered successes of the Bohr theory. F

**106.** Bohr could never really explain why an electron was limited to certain orbits. De Broglie explained this by showing that electrons in Bohr's allowed orbits

a. form standing-wave patterns about the nucleus.
b. have elliptical orbits like the planets around the sun. F
c. occupy a continuum of orbits but only radiate from some. F
d. obey Maxwell's equations. F
e. None of the above. F

**107.** Bohr gave the following reason for the electron in the hydrogen atom existing only in certain discrete energy levels.

a. This agrees with Newtonian mechanics. F
b. This agrees with Maxwell's equations. F
c. This was implied by the Rutherford atom F
f. All of the above (a through c) were cited. F
d. He simply postulated it, offering no logical basis. T
e. None of the above accurately reflects Bohr's published reasoning. F

[NOTE that lettering of answers here is out of order – use LETTER to identify answer on NCS sheet]

**108.** Two hydrogen atoms have electrons in the n = 3 energy level. One of the electrons jumps to the n = 2 level, while the other jumps to the n = 1 level. Which property is the same for the two photons that are emitted?

a. velocity  All photons have velocity c.
b. frequency F
c. energy F
d. color F
e. wave length F
f. None of the properties a) through f) above is the same for the two photons. F
g. All of the properties a) through f) above are the same for the two photons. F

**109.** If 100 g of water at 100° C and 200 g of ice at 0° C are mixed together in a completely insulated container, what is the final equilibrium temperature, most nearly? Recall that the latent heat of fusion of ice is 80 cal/g,, and the specific heat of water is 1 cal./gm-°C.)

a. 0° C
b. 5° C
c. 10° C
d. 33° C
e. 67° C
f. None of the above is within 10% of the correct answer.

Heat ejected in cooling 100 g from 100° to 0°C is
$Q_H^{OUT} = (100)(100)(1)$ cal/gm °C = 10,000 cal.
But $Q^{IN}_{MELT}$ to melt 200 g of ice into water at 0°C is
$Q^{IN}_{MELT} = (200)(80) = 16{,}000$ cal > 10,000 cal available from Hot $H_2O$
Conclude Hot $H_2O$ cools to 0° & final mixture has T=0°C: Mixture of ice & $H_2O$

**110.** You exert a force of 31.4 N on the head of a thumbtack. The head of the thumbtack has a radius of 1.0 mm. What is the pressure on your thumb, most nearly? (1 Pa = 1N/m$^2$.)

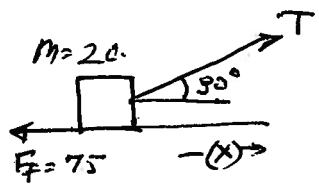
a. $10^{-6}$ Pa
b. $10^{-5}$Pa
c. 1 Pa
d. $10^5$ Pa
e. $10^7$
f. None of the above is within 10% pf the correct answer.

$$P = F/A = \frac{31.4\,N}{\pi R^2} = \frac{31.4\,N}{(3.14)(10^{-3}\,m)^2} = 10 \times 10^6 \frac{N}{m^2} = 10^7\ Pa$$

**The remaining problems, starting on the next following page, may require more than average numerical analysis.**

**111.** A rope is used to drag a box across a rough warehouse floor. Its angle is 30 degrees above the horizontal, and its tension is T. If the box has a mass of 20 kg, feels a frictional drag force of 75 N, and is accelerating horizontally at 0.5 m/s$^2$, what is the value of T?

a) 10N;
b) 65 N;
c) 75 N;
d) 85 N;
e) 95 N.




$F_x^{NET} = Ma_x = F^T + F_{fr}$

$T\cos 30° - 75 = 20(0.5)$

$T\cos 30° = 10 + 75$

$T = 85/0.866 = 98\ N \approx 10$ (a)

**112.** A 88-kg crate is being pushed across a horizontal floor by a horizontal applied force of +220 N. If the coefficient of sliding (kinetic) friction, $\mu_k = 0.25$, and the velocity is +7.5 m/s at time t = 0, how far does the crate move in the next 10 seconds, most nearly ?

a) 75 m;
b) 125 m;
c) 200 m;
d) 282 m;
e) 350 m;
f) None of these answers is within 10% of the correct answer.

$F^{App} = +220\ N$

$F^{fr} = -|N|\mu_k = -(88)(10)(0.25) = -220\ N$

N.I. $F^{NET} = F^{App} + F^{ff} = +220 - 220 = 0 = Ma \Rightarrow a = 0.$

$x(t) - x(0) = v_{0x}t + 0$

$= (7.5)(10) = 75m$

**113.** A 1200-kg roller coaster starts from rest at a height of 30 m. It travels downhill 60 m under a frictional force of 400 N to the flat crest of a hill that is 28 m high. What is its kinetic energy at the top of the 28 m hill, most nearly ?

a) 360,000 J;
b) 24,000 J;
c) 12,000 J;
d) 6,000 J;
e) 3,000 J;
f) 0 J.

$(ME)_i - W_f = (ME)_f$ Cons of ENERGY

$(KE)_i + (PE)_i - W_f = (KE)_f + (PE)_f$ & use $PE = Mgh$

$W_f = F_f \cdot \Delta X = (400)(60)\,N = 24{,}000\,N.$

$0 + (1200)(10)(30) - 24{,}000 = (KE)_f + (1200)(10)(28)$

$(12000)[30-28] - 24{,}000 = (KE)_f$

$0 = (KE)_f$

**Scenario for 114-115.** Suppose that a moon of Jupiter travels in a circle about the planet at a distance of $1.6 \times 10^{10}$ m once in every 10 days, and that has a mass of $3 \times 10^{22}$ kg. Then place the best answers to the following ***two*** questions into your NCS answer sheet.

**114.** If the speed of the moon is written approximately as $10^n$ m/day, then, most nearly, the speed is :

a) $10^2$ m/day;
b) $10^4$ m/day;
c) $10^6$ m/day;
d) $10^8$ m/ day;
e) $10^{10}$ m/ day
f) $10^{12}$ m/ day
g) $10^{14}$ m/ day

$v = 2\pi R/T = \frac{(2\pi)(1.6\times10^{10})}{10\text{ days}}\,m = \frac{10^{11}}{10} = 10^{10}\ m/day$

**115**. Also the acceleration of the moon is most nearly:

a) $0.6X10^3$ m/(day)$^2$;
b) $0.6X10^7$ m/(day)$^2$;
c) $0.6X10^{10}$ m/(day)$^2$;
d) $0.6X10^{13}$ m/(day)$^2$;
e) $0.6X10^{16}$ m/(day)$^2$
f). $0.6X10^{19}$ m/(day)$^2$

$a = v^2/R$ For uniform circular motion

$= \left(\frac{10^{10}\,m}{day}\right)^2 \times \frac{1}{(1.6X10^{10}\,m)} = \frac{10^{20-10}}{1.6} \frac{m}{(day)^2} = 6.25X10^9 \frac{m}{sec}$

$= 0.6X10^{10}$ (c) most nearly

**116** An observer drops a ball in a train traveling along a straight, horizontal track with a constant acceleration of 13.3 m/sec$^2$ in the forward direction. The observer is unaware of the acceleration and notices that the ball falls in a straight line that is slanted toward the back of the train. The acceleration of the ball along this line has a magnitude, most nearly equal to:

a) 5 m/s$^2$;
b) 7.5 m/s$^2$;
c) 10 m/s$^2$;
d) 10.6 m/s$^2$;
e) 12.5 m/s$^2$;
f) 14.1 m/s$^2$.
g) 16.6 m/ s$^2$

$-mA = F_{pseudo} = -(13.3)m$

$mg = F_G = -(10)m$

NI $F_{phys} + F_{pseudo} = \sqrt{(13.3)^2+(10)^2}\,m \Rightarrow a = \sqrt{276.9}$

$= 16.6$ m/sec$^2$

**117.** Two objects (e.g. an electron and a positron), each of rest mass, m, and each traveling with a speed of 0.8c, collide head-on and annihilate in the collision entirely into electromagnetic radiation. How much energy is emitted as radiation?

a) $mc^2$;
b) $1.25\ mc^2$;
c) $1.67\ mc^2$;
d) $2.0\ mc^2$;
e) $2.5\ mc^2$;
f) $3.34\ mc^2$.

$$E^{TOT} = E_1^{TOT} + E_2^{TOT} = \gamma_1 m_1 c^2 + \gamma_2 m_2 c^2$$

$$= \frac{mc^2}{\sqrt{1-(0.8)^2}} \times 2 = \frac{2}{(0.6)} mc^2 = 3.33\ mc^2$$

**118.** A train is traveling along a straight, horizontal track at a constant speed of $v = 0.9999995c = (1.0 - 5.0\times10^{-7})c$. A warning light on the ground flashes once each second.

An observer in the train measures the time between flashes to be, most nearly:

a) $10^{-3}$ s;
b) $10^{-2}$ s;
c) $10^{-1}$ s;
d) 1 s;
e) $10^2$ s;
f) $10^3$ s;
g) $10^4$ s;
h) $10^5$ s;
i) $10^6$ s;
j) $10^7$ s.

$\Delta t = \gamma \Delta t'$ & $\Delta t' = 1$ sec

$\gamma = \frac{1}{\sqrt{1-(v/c)^2}}$ & write $v/c = 1-\epsilon$

THEN $\epsilon = 5\times10^{-7}$

& $\gamma = \frac{1}{\sqrt{1-(1-\epsilon)^2}} = \frac{1}{\sqrt{\cancel{1}-\cancel{1}+2\epsilon-\cancel{\epsilon^2}}} = \frac{1}{\sqrt{2\cdot5\times10^{-7}}} = \frac{1}{\sqrt{10^{-6}}} = 10^{+3}$

Neglect $\epsilon^2 \ll 2\epsilon$

$\Delta t = 10^3\ \Delta t' = 10^3$ sec

**119.** One liter of gaseous (diatomic) oxygen combines completely with two liters of gaseous (diatomic) hydrogen to form a gas of water molecules (steam), when all of the gases are contained at the same temperature and pressure. One concludes from this that a water molecule has twice as many hydrogen atoms as it has oxygen atoms. If one also knows the volume of the steam finally produced (at the same temperature and pressure as the original hydrogen and oxygen), one can also choose the correct formula for water from the chemical formulas, $H_2O$, $H_4O_2$, and $H_6O_3$, etc…, all of which have twice as many hydrogen atoms as oxygen atoms in each molecule, as required.
Then suppose that the correct formula for the water molecule were $H_6O_3$, and compute the volume (at the same temperature and pressure) of steam finally produced. The final volume in that case would be, most nearly:

a) 6 liters;
b) 3 liters;
c) 1 liters;
d) 0.67 liter;
e) 0.33 liter;
f) 0.17 liter;

If correct formula were $H_2O$, 1 liter of $O_2$ would produce 2 l of $H_2O$.

Then if correct formula were $H_6O_3$ only 1/3 as many $H_6O_3$ molecules would be produced (since each $H_6O_3$ molecule takes 3 O atoms instead of 1). Then $V_{H_6O_3} = 2/3\ l. = 0.67\ l$

**120.** A certain pendulum with a length of 2.0 m has a period of 2.8 s on earth. If the pendulum is moved to a planet where the gravitational force is half as great as earth's, and its length is increased to 4.0 m, what is its new period?

a. 11.2 s
b. 5.6 s
c. 2.8 s
d. 1.4 s
e. 0.7 s
f. None of the above is correct within 10%.

$T = 2\pi\sqrt{L/g} \rightarrow T' = 2\pi\sqrt{\frac{2L}{g/2}} = 2\pi\sqrt{4}\sqrt{L/g}$

$L \rightarrow 2L$
$g \rightarrow g/2$

$= 2T$
$= 2\,(2.8) = 5.6\,sec$

******************End of Exam******************