Phys 117 F06 Final Exam Solutions

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Physics 117 Final Exam, Version A, Page 1 of 26

A) GENERAL INSTRUCTIONS

This exam consists of 120 questions worth two points each for a maximum of 240 points.

ALL ANSWERS MUST BE ENTERED INTO THE NCS ANSWER SHEET BY MEANS OF HEAVY BLACK MARKS WITH A NUMBER 2 PENCIL. (Only a pencil mark will work; the optical scanner cannot read inked answers no matter what color or how dark.)

The questions are numbered from 1 to 60: make sure you enter your single letter answer into the answer line with the same number as the question you are answering.

Only the computer readable NCS answer sheet will be collected. Keep this exam for you future use.

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B) PREPARE YOUR ANSWER SHEET IN ADVANCE:

1) SIGN YOUR PERSONAL SIGNATURE INTO THE TOP MARGIN ABOVE THE NAME BOX of the NCS SHEET.
2) PRINT YOUR NAME, **FAMILY NAME FIRST**, INTO THE BOXES PROVIDED AND DARKEN THE CIRCLE FOR THE CORRESPONDING LETTER BELOW EACH BOX
3) INSERT YOUR STUDENT ID NUMBER UNDER "IDENTIFICATION NUMBER" AND DARKEN THE CORRESPONDING CIRCLES BELOW EACH NUMBER.
4) MAKE NO STRAY MARKS ON THE ANSWER SHEET AND ERASE CLEANLY IF NECESSARY.

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C) GENERAL ADVICE

Many students will not have time to finish this exam if they proceed at a leisurely pace. Therefore it is probably advantageous to earmark time-consuming items for later attention and skip forward to questions that can be answered more easily. No subtractions will be made for wrong answers, so that last minute best guessing is probably an advantageous strategy.

IF YOU NEED HELP, ASK!.....AND ASK EARLY RATHER THAN LATE.

ALSO FOR FAIRNESS' SAKE, PLEASE STOP WRITING WHEN THE EXAM ENDS. A PENALTY OF 8% OF THE RAW SCORE MAY BE IMPOSED UPON STUDENTS WHO TRY TO TAKE UNFAIR ADVANTAGE OF THE COLLECTION PROCESS BY CONTINUING TO WRITE AFTER THE END HAS BEEN ANNOUNCED.

(NOTE that a matching question table comprises questions 6 through 15 on page 3. Since these questions may go quickly, you may wish to treat them out of order.)

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Physics 117 Final Exam, Version B, CORRECTIONS Page 0

Please correct the following typographical errors in the printed exam. It is suggested that you **insert the corrections immediately** into your copy of the exam, lest the correction be overlooked when you come to that point during the exam period..

Question #112:

line 1: Replace ~~{....220N...}~~> {...+220N...};
line 2: Replace ~~{...sliding friction....}~~> {...sliding (kinetic) friction, μ_k,...);
line 2: Replace ~~{...speed is 7.5....}~~> {...velocity is +7.5...).

Question #113

line 1: Delete the word, "frictionless".

Question #118:

line 2: Replace ~~{...v= 0.9995c = (1-0.5x10^{-3})c.... }~~>{...v= 0.99995c = (1-5x10^{-5})c....}.

The following additional corrections were announced on the blackboard during the exam:

Question #44: This question is inconsistently posed and any answer will be accepted as correct.

Question #107:

line 6: Replace {c) all of the above....} by {f) all of the above....}: I.e, re-label second of two c) answers as answer f).

[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. Identify your exam on answer line #1 of your NCS answer sheet. From the top line of this page (above), this is

a. Version A
b. Version B

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 an hour later than 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 decreasing rate
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.

NOTE: RATE of increase of Speed (i.e acceleration) goes to zero as Speed approaches terminal velocity.

4. If the mass and weight of an astronaut are measured on the earth and on the moon, the masses will be found to be _____ and the weights, _____.

a. the same ... the same
b. different ... different
c. the same ... different
d. different ... the same
e. None of the above.

5. 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)(9.4X10^8km/orbit)(1day/24hr)(3600sec/1hr)(10^3m/1km)
b. (1orbit/365day) (9.4X10^8km/orbit)(1day/24hr)(1hr/3600sec)(10^3m/1km)
c. (1orbit/365day) (9.4X10^8km/orbit)(24hr/1day)(1hr/3600sec)(1km/10^3m)
d. (1orbit/365day) (1orbit/9.4X10^8km)(1day/24hr)(1hr/3600sec)(10^3m/1km)
e. (1orbit/365day) (9.4X10^8km/orbit)(1day/24hr)(1hr/3600sec)(1km/10^3m)
f. None of the above conversions yields the correct result.

The next ten questions (#6-#15) request you to matching of the person 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.

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

Continue with 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 30 seconds to accelerate from zero to 300 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. 10^9m/sec^2
f. None of the above is within a factor of 3 of the correct acceleration.

$\bar{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{(300\times10^3\ m/3600\ sec - 0)}{30\ sec} = \frac{8\times10^5}{(3.6\times10^3)(3\times10)}\ m/sec^2$

$= 2.78\ m/sec^2$

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

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.

$d(4) = \frac{1}{2} g t^2 = \frac{10}{2}\cdot 12 = 60$

$d(2) = 20$

$d(4) - d(2) = 60\ m$

18. A ball is thrown straight up into the air with an unspecified velocity. If we do not ignore air resistance, the acceleration of the ball as it is traveling upward 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.
d. zero
e. None of the above, because the acceleration depends upon the speed.

$\vec{F}_G + \vec{F}_f = m\vec{a}$ since $\vec{F}_f$ opposes $\vec{v}$ it is directed DOWNward

$-mg - |F_f| = m\vec{a} \Rightarrow \vec{a} = -\frac{mg}{m} - \frac{|\vec{F}_f|}{m}$

& Magnitude of a: $|a| = \left|g + \frac{|F_f|}{m}\right| > g$

19. A car traveling westward at 21 m/s turns around and travels eastward at 14 m/s. If this takes place in 7 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%.

$\bar{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{21 - (-14)}{7} = \frac{35}{7} = 5\ \frac{m}{(sec)^2}$

[Taking WEST to be + & EAST - directions]

20. You want to launch a rocket vertically so that it will reach the altitude of a light plane 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%

Time to fall 500m is given by $d = \frac{1}{2}gt^2 \Leftrightarrow 500 = \frac{10}{2}(t_f)^2$

i.e $t_f = \sqrt{100} = 10$ sec. But t_f = same as t_{MAX} = time to reach MAX height. Then $v(t_{MAX}) = 0 = v_0 - g t_{MAX} \Rightarrow v_0 = g t_{MAX}$

$= 10 \cdot 10 = 100\ \frac{m}{sec}$

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

a. the object has inertia. [No! (photons)]
b. there are no forces acting on the object. No! (No NET FORCE)
c. there must be at least two forces acting on the object. NO
d. there can be no more than two forces acting on the object. NO
(e.) The vector sum of all the forces acting on it is zero YES!
f. None of the above completions yields a true statement..

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
f. None of the above.

& Also the NET FORCE on both $\equiv 0$ ($\vec{a} = 0$!)

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
c. 10 m/s^2 upward
d. 20 m/s^2 downward
e. 20 m/s^2 upward
f. None of the above.

acceleration $= -g =$ constant.

24. A parachutist reaches terminal speed when

a. her weight goes to zero.
b. the force of air resistance exceeds her weight.
(c.) the force of air resistance equals her weight.
d. the force of air resistance equals her mass.
e. only when she spreads our her limbs to increase the air resistance.
f. None of the above completions yields a true statement.

$a = 0 \Rightarrow$
$F^{NET} = 0 = F_{Res} + W \Rightarrow |F_{Res}| = |W|$
where $W = mg =$ Weight

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.
e. do none of the above.

$F^{NET} = F^{APP} + F_{fr} = 0$ iff $F^{APP} = 75N$
If $F^{APP} = 90$, then
$F^{NET} = 90 - 75 = 15 > 0$
and $a > 0$.

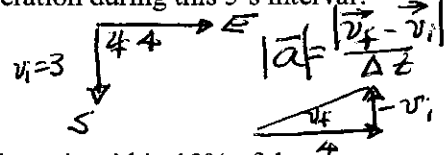
26. A book sits at rest on a table. Which force does Newton's third law tell us is equal and opposite to the gravitational force acting on the book?

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

, since Gravitational force is due to EARTH's mass.

27. A migrating bird is initially flying south at 3 m/s. To avoid hitting a high-rise building, the bird veers and changes its velocity to 4 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.



$|\vec{a}| = \left|\frac{\vec{v}_f - \vec{v}_i}{\Delta t}\right| = \frac{\sqrt{4^2 + 3^2}}{5} = \frac{5}{5} = 1\ m/sec^2$

28. A red ball is thrown straight down from the edge of a tall cliff with a speed of 60 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?

Green comes to top when $v(t_{MAX}) = 0 = v_0 - gt_{MAX} \Rightarrow t_{MAX} = \frac{60}{g} = 6$
& it takes same time to fall back to launch height.
Then Green starts DOWN from launch point with $|v| = 60$, just (12) sec later.

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%.

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 $|v| = \sqrt{v_x^2 + v_y^2}$ is greater when $v_x^2 > 0$.
e. The bullet that was dropped.
f. It is not possible to say with the information given.

30. You are applying a 500-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 $\mu = 0.7$ is the coefficient of static friction.. The frictional force exerted by the floor on the freezer is

just equal to the applied force, since $\vec{a} = 0 \Rightarrow F_{NET} = 0$

(a.) 500 N
b. greater than 500 N but less than 700 N
c. greater than 700 N but less than 1000 N
d. 700 N
e. 1000 N.

31. A ball with a weight of 20 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?

F_{GRAV} = Weight = Constant

a. zero
b. 10 N upward
c. 10 N downward
d. 20 N upward
(e.) 20 N downward
f. At the top of the trajectory the force on the ball is actually horizontal
g. None of the above.

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.

Since $\vec{a}$ is upward $F_{Bungee} > F_{weight}$
As cord stretches F_{BUNGEE} increases (Cf. spring force)

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.

$x(16) - x_0 = v_0 t + \frac{1}{2} a t^2 = 16(16) - \frac{2}{2}(16)^2 = 0$

34. What is the acceleration due to earth's gravity at a distance of 30 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.

$\tilde{g}(30R_E) = \frac{F_G}{m} = \frac{1}{m}\frac{GM_E m}{(30R_E)^2} = \frac{1}{900}\left(\frac{GM_E}{R_E^2}\right) = \frac{g}{900} = \frac{10}{900} = \frac{1}{90}$ m/sec^2
$\approx 10^{-2}$ m/sec^2

35. Suppose that a certain planet, P, has a radius of about 2.0 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.

$\tilde{g}_P = G\frac{M_P}{(R_P)^2} = \frac{G(8M_E)}{(2)^2 R_E^2} = \frac{8}{4} G\frac{M_E}{R_E} = 2g = 20$ m/sec^2

36. Two objects have different masses but the same kinetic energies. If you stop them with the same 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.

$F \cdot \Delta x = \Delta(KE)$: F & Δ(KE) are SAME so that Δx = SAME

37. Two objects have different masses but the same momenta. If you stop them with the same 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 $F\Delta t = \Delta p$ says that they stop in the SAME Δt since F & Δp are SAME

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 since $\vec{F}_c \perp \Delta x$ so that $F \Delta x \cos\theta = 0$
b. 2 J
c. 4.5 J
d. 6 J
e. 9 J
f. None of the above is within 10% of the correct answer.

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 1 J
(b.) gain of 10 J by CONSERVATION of ME for CONSERVATIVE forces.
c. loss of 1 J
d. loss of 10 J
e. the kinetic energy gain is zero
f. None of the above

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 conserved during a collision, because its value varies during the collision, it can not be a conserved quantity.
f. None of the above answers is correct.

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

a. from knowledge of the earth's mass density and volume
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' EXPT.
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. FALSE
b. The first form does not work because it requires two masses. FALSE - general form always works!
c. The first form is not valid near the surface of the earth. "
d. The simpler form is easier to calculate and therefore preferable to the first. NOT a VALID REASON
(e.) None of the above is a valid and sufficient reason for using the second form.
[N.B. USE of $F=mg$ is validated by its accurate reproduction of $F = G\frac{M_E m}{R^2}$ near earth's surface]

43. A 300-kg satellite experiences a gravitational force of 1000 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 $r_0 = R_E$ 300 kg feels $F_G = 3000$ N
(b.) 0.7 R_E at $r = 2R_E$ $F_G(2) = \frac{1}{2^2} F_G(1) = \frac{3000\text{N}}{2^2} = 1000\text{ N} \Rightarrow 2^2 = 3$
c. 1.4 R_E $2 = \sqrt{3} = 1.732$
d. 1.7 R_E $r_h = 2R_E = \sqrt{3}R_E = (R_E + h) \Rightarrow h = (1.732 - 1)R_E \approx 0.7 R_E$
e. 2.0 R_E
f. 3.0 R_E
g. None of the above is within 10 % of the correct height.

e delete (in mph) to get answer (g)

44. You have a mass of 70 kg. How fast would you have to run to have the same momentum as a truck (m = 36,000 kg) rolling along at 1 km per hour?

a. 10^7 m/s
b. 10^6 m/s
c. 10^5 m/s
d. 10^4 m/s
e. 10^3 m/s
f. 10^2 m/s.
(g.) None of the above is within 10% of the correct answer.

$MV = m \cdot v \qquad V = \frac{mv}{M} = \frac{3.6\times10^4\ \text{kg}}{70\ \text{kg}} \cdot \frac{10^3\ \text{m}}{3.6\times10^3\ \text{sec}} = \frac{10^4}{70}$

$= 1.43\times10^2$ m/sec

differs by 40% from 10^2 m/sec

[NOTE: all answers to this question were considered correct because "(in mph)" made the question in consistent with the answers offered.]

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. None of the above.

46. A very hard rubber ball (m = 0.6 kg) is falling vertically at 1 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 0.03 s, what is the average force exerted by the floor on the ball during the bounce?

(a.) 40 N
b. 90 N
c. 200 N
d. 400 N
e. None of the above is within 10% of the correct answer.

$\bar{F}\cdot\Delta t = \Delta p = (0.6)(1) - (0.6)(-1) = 1.2\ \text{kg m/s}$

$\bar{F} = \frac{1.2}{0.03} = 40\ N$

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 BECAUSE TOTAL MOMENTUM of an ISOLATED SYSTEM IS CONSERVED
f. There is not enough information to say.
g. None of the above is correct.

48. A 80-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 5 m high?

a. 4000 J
(b.) 12,000 J
c. 40,000 J
d. 120,000 J
e. None of the above answers is within 10% of the correct result.

By (Cons of ME for conservative (GRAVITY) force.)

$(ME)_i = (PE)_i + (KE)_i = 80\cdot g\cdot h_i = (PE)_f + (KE)_f$

$80\,g(h_i - h_f) = 80\cdot(10)(15) = (KE)_f$

$= 12000\ J$

49. How much energy is required to light a 600-W bulb for 40 h? (1 W = 1 Joule/sec)

a. 8.6×10^5 J
b. 1.4×10^4 J
c. 8.6×10^3 J
d. 2.4×10^2 J
(e.) None of the above answers is within 10% of the correct result.

$E = 600\ \frac{J}{sec} \times 40\ hr \times \frac{3600\ sec}{hr} = (6)(4)(3.6)\times10^{2+1+3}$

$= 86.4\times10^6 = 8.6\times10^7\ (>> 8.6\times10^5\ !)$

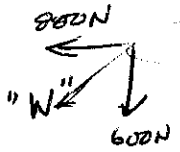
50. A ball is thrown horizontally at 30 m/s from a flatcar that is moving in a straight line at 40 m/s. Relative to a person on the ground, what is the horizontal speed of the ball when it is thrown directly towards the back of the flatcar?

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.

$v = v' + V = -30 + 40 = 10$ m/sec

51. A person who weighs 600 N when at rest is riding in the rotating cylinder ride. The cylinder rotates fast enough to create an 800-N centrifugal pseudoforce 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.



$W = \sqrt{(800)^2 + (600)^2} = \sqrt{(10^2)(100)^2} = 10^3$ 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 6.4×10^6 m)

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

$\frac{v^2}{R_E} = g \quad v = \sqrt{gR_E} = \sqrt{10 \cdot (6.4) \times 10^6}$

$v = \sqrt{64 \times 10^6} = 8 \times 10^3$ m/sec

53. A 160-kg satellite orbits a distant planet with a radius of 4000 km and a period of 280 min. From the radius and period, you calculate the satellite's acceleration to be 4.5 m/s^2. What is the gravitational force on the satellite, most nearly?

a. 50.4 N
b. 90 N
c. 720 N
d. 12,000 N
e. None of the above is within 10% of the correct value.

$F = ma = (160)(4.5)\frac{kgm}{sec^2} = 720N$

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

(DEF. of INERTIAL FRAMES)

55. In his theory of special relativity, Einstein
- a. abandoned the Galilean principle of relativity. NO!
- b. abandoned Maxwell's equations for electricity and magnetism. NO!
- c. reconciled the apparent conflict between the Galilean principle of relativity and Maxwell's equations. NO
- d. postulated the existence of an absolute reference system. NO!
- e. postulated that the speed of light is constant in vacuum, and the same in all inertial frames. YES
- f. All of the above completions yield true statements. NO
- g. None of the above. NO

NO RECONCILIATION was needed: He kept both!

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.
- b. is independent of the motion of the receiver.
- c. is independent of the motion of the source.
- d. is independent of the direction of propagation
- e. In fact, the second postulate requires all of the above statements, a through d.
- f. In fact, the second postulate requires none of the statements a through d.

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 — Since its light signal reached you before it reached her (as she moved forward from you).
- 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.
- b. Yes, but only if he goes faster than light.
- c. Not unless he is able to take a breath along the way.
- d. Yes, because in his frame his biological clock slows down to give him more time
- e. Yes, because in his frame of reference the distance he needs to travel is contracted to a much smaller value. (... & as small as necessary if v can come arbitrarily close to c!)
- f. None of the above comments is true and relevant to the question

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.
- b. the twin who made the trip, because he had to accelerate to turn around, AND in that acceleration all of his system's clocks had to be re adjusted to his new velocity in the opposite direction so that his claims about elapsed times are invalid.
- c. Actually, both are mistaken: they are the same age, because the speed was held constant out and back.
- d. The answer depends upon the details of the turnaround.
- e. None of the above statements is true.

60. If you approach a light beacon while traveling at one-half 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 = SAME IN EVERY FRAME of Reference.
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. None of the above is within 10% of the correct answer.

$\frac{2\,kg}{2\times10^{-2}}$ can make 100 sandwiches, which require 0.5 kg of HAM
Then bread is used up & HAM is left over & sandwiches have mass of 2.5 kg

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.
b. showed that heat was not a fluid.
c. were used to define the calorie. (No - calorie defined by Sp Heat of H_2O)
d. showed that heat could be converted 100% to mechanical energy. (No! 2nd LAW)
e. All of the above.
f. None of the above.

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.
b. have no internal structure.
c. are indestructible.
d. do not interact except when they collide.
(e.) sometimes break up into their separate atoms – Our gas allowed NO BREAK-UP
f. All of the above (I.e., None of the properties a) through e) above is an assumed characteristics of our ideal gas.)

64. The first law of thermodynamics

a. is a restatement of the law of conservation of energy which includes heat as energy. ✓
b. allows that internal energy can be completely converted into work. ✓
c. includes kinetic and potential energy at the atomic/molecular level in its internal energy. ✓
d. guarantees that the work extracted by a *cyclic* heat engine can never be less than the net heat input. ✓ because $\Delta U = 0$ for each cycle $\Rightarrow Q^{IN} + W^{IN} = 0$
(e.) All of the statements a) through d) above are true of the first law. $\Rightarrow Q^{IN} = W^{OUT}$
f. None of the statements a) through d) above are true of the first law.

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 10^3 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

$P_f V_f = C T_f^A \Rightarrow \frac{P_f V_f}{P_i V_i} = \frac{T_f}{T_i} = \frac{(1)V_f}{(1)V_f} = \frac{T_f^A}{T_i^A} \Rightarrow T_f^A = \frac{T_i^A V_f}{V_i}$

& $P_i = P_f = 1\,atm$

$T_i^C = 27°C = 300\,K = T_i^A$

Then $T_f^A = 300 \cdot \frac{10^3}{10^5} = 3\,K$

& $T_f^C = T_f^A - 273 = -270°C$

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!
(e.) All of the statements a) through d) above are true. (TRUE: $0 = \Delta S = \frac{Q^{IN}}{T_H} - \frac{Q^{OUT}}{T_C} \Rightarrow T_H = T_C$)
f. None of the statements a) through d) above is true.

67. Climates near the coasts tend to be more moderate than in the middle of the continent
(a.) Because water has a relatively high specific heat. so that it can absorb or emit heat in large amounts with small change in T.
b. Because water has a high latent heat of vaporization. X
c. Because the coasts have lower elevations. X
d. Because it rains a lot on the coasts. X
e. Because breezes blow downhill from the mountains. X
f. None of the above: coastal climates are not, in fact, more moderate than inland climates. False

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 1ℓ of Al has a much larger mass than 1ℓ of Air (both at T=20° P=1 atm)
f. There is not enough information to justify a statement.

69. Thirty two liters of an ideal gas are cooled from 1200 K to 150 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.

$\frac{P_f V_f}{P_i V_i} = \frac{T_f}{T_i} \Rightarrow V_f = V_i \frac{150}{1200} = 32\ell \times \frac{1}{8} = 4\ell$

since $P_f = P_i$

70. What would happen to a pot of water on a hot 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.
b. The water would boil at a higher temperature.
(c.) The water would all turn to steam very rapidly. & pot would boil DRY.
d. The water would not form steam.
e. None of the above.

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 because T remains constant until all liquid has boiled
c. 78 K
d. 196 K
e. 300 K
f. None of the above is within 10% of the correct answer.

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.

$32\,g\ O + 4\,g\ H = 36\,g\ H_2O$ & 4g H are leftover.
Then 40 g is just outside 110% of 36 g = 39.6 gm
& 32 + 3.2 = 35.2 : 32 g is NOT within 10% either
Then both (d) & (e) are wrong & (f) is correct

73. If you triple the absolute temperature of an ideal gas and double 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

$\frac{P_f V_f}{P_i V_i} = \frac{k T_f}{k T_i} = 3 = \frac{2 V_f}{V_i} \Rightarrow V_f = \frac{3}{2} V_i$
since $\frac{T_f}{T_i} = 3$ & $\frac{P_f}{P_i} = 2$

74. A steel railroad rail is 556 m 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. 0.001 cm
b. 0.01 cm
c. 0.1 cm
d. 1.0 cm
(e.) 10.0 cm

$\Delta L = L_0 \alpha \Delta T = 556\,m \times (1.2 \times 10^{-5}) \times (33-18)\,K \times \frac{100\,cm}{m}$
$= (5.52)(1.2)(1.5) \times 10^{2-5+1+2}\,cm = (10) \times 10^{5-5}\,cm$
$= 10\,cm$

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 quadrupled while the volume reduced to half its original value?

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.

If $\langle KE \rangle_{AVG} = \frac{3}{2} k T_A$ is quadrupled, T_A increases 4x & $\frac{V_i}{V_f} = 2$.
$\frac{P_f V_f}{P_i V_i} = \frac{k T_f}{k T_i} = 4 = \frac{P_f}{P_i} \cdot \frac{1}{2} \Rightarrow P_f = 8 P_i = 160\,atm.$

76. One liter of an ideal gas is heated from 260 °C to 1325 °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

$\frac{P_f V_f}{P_i V_i} = \frac{kT_f}{kT_i} = \frac{1\,V_f}{1\,V_i} = \frac{(1325+273)}{(260+273)} = 3.00$

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 2nd LAW
f. All of the above transformations are in fact possible.

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 that can do mechanical work by extracting thermal 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. All of the above.

79. A heat engine

a. converts thermal energy into mechanical energy. ✓
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 (Carnot's Limit)
e. All of the above.
f. None of the above.

80. The second law of thermodynamics

a. says that it is impossible to reach the absolute zero of temperature. 3rd Law
b. says that the total entropy of an isolated system tends to increase. T
c. is the basis for the definition of temperature. No 0th LAW
d. is the basis for the definition of internal energy. No: 1st LAW
f. is simply the law of conservation of energy with heat included as a form of energy. No: 1st LAW
g. None of the above completions yields a true statement. F

81. Which of the following disagrees with the second law of thermodynamics?

a. Heat naturally flows from hot objects to cold objects. Agrees
b. No engine can transform all of its heat input into mechanical work. "
c. The entropy of an isolated system can never decrease. "
d. Perpetual motion machines are possible, but difficult. Dis Agrees: Perp Motion Machine is NOT possible
e. Refrigerators cannot run without work being done on them Agrees
f. All of the above agree with the second law of thermodynamics, and none disagrees.

82. How many different outcomes are there for the flipping of four 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%.

$2^4 = 4 \cdot 4 = 16$ All Heads 1, Tails 1, $= 2$ i.e. $\frac{2}{16} = \frac{1}{8} = 12.5\%$

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.

$\frac{W^{MAX}}{Q_{IN}} = \frac{\eta_{MAX} \cdot Q_{IN}}{Q_{IN}} = \eta_{CARNOT} = 1 - \frac{T_c}{T_H} = 1 - \frac{280}{300} = 0.07$

$T_H = 27 + 273 = 300K$ / $T_c = 7 + 273 = 280K$

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. YES it gave up heat
b. entropy of the water has increased. YES it accepted "
c. net change in entropy of the system is positive. YES since $T_W < T_{Metal}$
d. final temperature of the system lies between the initial temperatures of the metal and the initial temperature of the water. TRUE
e. All of the statements a) through d) above are true. TRUE
f. None of the statements a) through d) above is true

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.

since $\eta = 1 - \frac{T_{out}}{T_{IN}}$ = efficiency

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.

$\eta_{ACTUAL} = \frac{W_{out}}{Q_{IN}} = \frac{Q_{IN} - Q_{out}}{Q_{IN}} = \frac{4800 - 1200}{4800} = 0.75 = 75\%$

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. 570° C
c. 830° C
d. 1000° C
e. 1250° C
f. None of the above is within 10% of the correct answer

$\eta_C = 0.4 = \left(1 - \frac{T^A_{out}}{T^A_{IN}}\right) \Rightarrow T^A_{out} = (1-0.4)T^A_{IN}$

$T^A_{IN} = \frac{T^A_{out}}{0.6} = \frac{(227+273)\,K}{0.6}$

$T^A_{IN} = \frac{500}{0.6} = 833.3\,K$

In centigrade units: $T^C_{IN} = 833 - 273 = 560\,^\circ C$

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?

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.

$1\,cal = 4.2\,J \Rightarrow 220\,J = 220\,J \times \frac{1\,cal}{4.2\,J} = 52.4\,cal$

Then Room energy increases by

$\Delta U^{Room} = Q_H^{out} = Q_C^{out} + W = (100 + 52.4)\frac{cal}{min}$

It increases by $152.4\frac{cal}{min}$

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. 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.

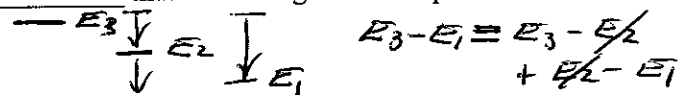
91. It was expected that an atom like that of the Rutherford model should be unstable because the electrons would spiral inward and collapse into the nucleus' volume in very short time periods. What was expected to cause this instability in Rutherford's model?

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

Because attractive force accelerates towards center but will not diminish radius of the orbit unless energy can be given off.

92. When light is incident on a metallic surface, the emitted electrons
a. are called photons. F
b. have arbitrarily high energies. F
c. have a maximum energy that increases with the intensity of the light. F
d. Are referred to as cathode rays. F
e. Become more numerous as the frequency increases. F
(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 greater than
(b.) is the same as
c. is less than
d. is not able to be compared with
e. 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. X
b. light is a wave phenomenon. X
(c.) light consists of particle-like wave packets, photons, each with energy e = hf . ✓
d. electrons boil off when they get hot enough. X
e The intensity of the electromagnetic field was the determinant of the electrons' energies. X
f. None of the above.

95. What is the frequency of the minute hand on a clock, most nearly?
a. 3600 Hz
b. 60 Hz
c. 1 Hz
d. 2 X10^{-2} Hz
(e.) 3 X 10^{-4} Hz
f. None of the above is within a factor of 2 of the correct frequency.

$\frac{1}{hour} = \frac{1}{hr} \times \frac{1hr}{3600 sec} = \frac{2.78 \times 10^{-4}}{sec} \approx 3 \times 10^{-4} Hz$

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) X
b. (M and L) X
c. (M and g) X
(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
d. inversely proportional to
e. None of the above.

$T = 2\pi\sqrt{L/g} \propto g^{-1/2}$

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. $v = \lambda f$ $v = f \times \lambda$ (only choice w $[v] = \frac{L}{T}$!)
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 Sound Wave speed is independent of frequency.
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?

$v = f \cdot \lambda = \frac{4}{sec} \cdot 30cm = \frac{120\,cm}{sec}$

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. as shown by EXPTS on PHOTO ELECTRIC EFFECT

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

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
b. number
c. minimum kinetic energy
d. maximum kinetic energy
e. charge
f. None of the above will increase with the stated change in color.

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

a. γ-ray, X ray, ultraviolet, visible, infrared, microwave Typo "(-ray" → γ-ray
b. infrared, visible, ultraviolet, X ray, radio
c. radio, infrared, X ray, visible, ultraviolet
d. radio, infrared, visible, ultraviolet, γ-ray
e. None of the above meets the ordering criterion stated.

From Ch 22 Fig 22-26 $\lambda_{RADIO} > \lambda_{MICROW} > \lambda_{Infr\text{-}Red} > \lambda_{VISIBLE} > \lambda_{uViolet} > \lambda_{X\,Ray} > \lambda_{\gamma\text{-}Ray}$

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. X
- 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. X

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, $2\pi rp = nh$. X Typo: $2\pi r p = h \cdot n$
- f. All of the above are considered successes of the Bohr theory.

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. YES
- b. have elliptical orbits like the planets around the sun. X
- c. occupy a continuum of orbits but only radiate from some. X
- d. obey Maxwell's equations. X
- e. None of the above.

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. +
- b. This agrees with Maxwell's equations. +
- c. This was implied by the Rutherford atom +
- ~~e.~~ (f) All of the above were cited. + Correx:
- (d.) He simply postulated it, offering no logical basis. ✓
- e. None of the above accurately reflects Bohr's published reasoning.

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 is same for all photons = c
- b. frequency X
- c. energy +
- d. color +
- e. wave length +
- f. None of the properties a) through f) above is the same for the two photons. X
- g. All of the properties a) through f) above are the same for the two photons. X

109. If 200 g of water at 100° C and 100 g of ice at 0° C are mixed with 300 g of water at 50° C 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.

a. 45° C
b. 54° C
c. 58° C
d. 70° C
e. None of the above is within 10% of the correct answer.

$Q^{IN}_{NET} = 0 = [200 \cdot 1 \cdot (100 - T_f) - 100 \cdot 80 - 100 (T_f - 0) + 300 (50 - T_f)] = 0$

$[2 \times 10^4 - 8 \times 10^3 + 15 \times 10^3] = T_f (200 + 100 + 300)$

$27 \times 10^3 = 600\, T_f \Rightarrow T_f = 45^\circ C$

110. You exert a force of 30 N on the head of a thumbtack. The head of the thumbtack has a radius of 3 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. None of the above is within 10% pf the correct answer.

$P = \frac{F}{A} = \frac{30N}{\pi (3 \times 10^{-3})^2 m^2} = \frac{30}{9\pi} \times 10^6 \frac{N}{m^2} = 1.06 \times 10^6$ Pa

The remaining problems 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 the its tension is T. If the box has a mass of 15 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?

0.5N; b). 37.5 N; c) 75 N; d) 82.5 N; e) 95.3 N.

$F^{NET}_x = m a_x$ in horizontal direction

$(F_{Tx} + F_f) = 11$

$(T \cos 30^\circ) - 75 = (15)(0.5)$

$T \cos 30^\circ = 75 + 7.5$

$T = \frac{82.5}{(0.866)} = 95.27$

112. A 40-kg crate is being pushed across a horizontal floor by a horizontal applied force of ~~120~~ +220 N. If the coefficient of sliding ~~friction is~~ (kinetic) friction, μ_k = 0.3, and the ~~speed is 7.5~~ 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) 262 m; e)350 m;

f) None of these answers is within 10% of the correct answer.

$F^{NET} = F^{APP} - |F_f| = 220 - 120 = Ma \Rightarrow a = \frac{100}{40} = +2.5\ m/sec^2$

$|F_f| = \mu_k M g = (0.3)(40)(10) = 120\ N$ (opposite to motion)

$x(t) - x(0) = v_0 t + \frac{1}{2} a t^2$

$= (7.5)(10) +$ ~~#12~~ force of +220 N

~~Sped~~ is → velocity is +7.5

~~Sliding~~ → sliding (kinetic) μ_k

delete

113. A 1200-kg ~~frictionless~~ roller coaster starts from rest at a height of 3 ... travels up and down 60 m under a frictional force of 400 N to the crest of a hill that is 26 m high. What is its kinetic energy at the top of the 26 m hill, most nearly ?

a) 36,000 J; b) 24,000 J; c) 12,000 J; d) 7,200 J; e) 4,800 J; f) 0 J.

Conservation of Energy $(ME)_i - W_{friction} = (ME)_f$

$(KE)_i + Mg h_i - (F_f \cdot d) = (KE)_f + Mg h_f$

$h_i = 30\ m$, $h_f = 26\ m$, $h_i - h_f = 4\ m$

$Mg(h_i - h_f) - (F_f \cdot d) = (KE)_f$

$(1200)(10)4 - 400 \cdot (60) = (KE)_f$

$(48{,}000 - 24000)\ J = (KE)_f$

Scenario for 114-115. Suppose that a moon of Jupiter travels in a circle about the planet at a distance of 1.6×10^8 m once in every 10 days, and that has a mass of 3×10^{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

$$\text{speed} = \frac{D}{T} = \frac{2\pi R}{T} = \frac{2\pi (1.6\times 10^8)\,m}{10\,d} = \frac{10\cdot 10^8}{10}\frac{m}{d} = 10^8\frac{m}{d}$$

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

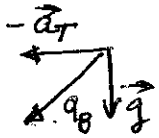
a) $0.6\text{X}10^4$ m/(day)^2; (b) $0.6\text{X}10^8$ m/(day)^2; c) $0.6\text{X}10^{12}$ m/(day)^2;
d) $0.6\text{X}10^{16}$ m/(day)^2; e) $0.6\text{X}10^{20}$ m/(day)^2.

$$a = v^2/R = \frac{(10^8)^2\,\frac{m^2}{(d)^2}}{(1.6)\times 10^8\,m} = \frac{10^8}{1.6}\frac{m}{(d)^2} = 6.25\times 10^7\frac{m}{(d)^2}$$

$$= 0.625\times 10^8\frac{m}{(d)^2}$$

116 An observer drops a ball in a train traveling along a straight, horizontal track with a constant acceleration of 7.5 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.



$|a_B| = \sqrt{(10)^2+(7.5)^2} = \sqrt{156.25} = 12.5\ m/sec^2$

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.

$E_{tot} = 2\cdot\gamma mc^2 = \frac{2mc^2}{\sqrt{1-(.8)^2}} = \frac{2}{\sqrt{.36}}\,mc^2$ for both electrons

$E_{emitted} = E_{tot} = 3.3\,mc^2$

Replace: ~~$0.995c = (1 - 5\times10^{-3})c$~~ $\rightarrow$ $0.99995c = (1 - 5\times10^{-5})c$

118. A train is traveling along a straight, horizontal track at a constant speed of $v = $ ~~$0.9995c = (1-0.5\times10^{-3})c$~~. 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;

Flashing Light on Ground is in frame moving w r t observer on train

Therefore its time is dilated for him

$$\Delta t_T = \gamma \Delta t'_G = \gamma \cdot 1\,\text{sec.}$$

$$\gamma = \frac{1}{\sqrt{1-(v/c)^2}} = \frac{1}{\sqrt{(1-v/c)(1+v/c)}} = \frac{1}{\sqrt{5\times10^{-5}/2}} = \frac{1}{\sqrt{10^{-4}}}$$

$$\gamma = 10^2 \text{ sec}$$

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_4O_2, 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) 8 liters; b) 4 liters; c) 2 liters; (d) 1 liter; e) 0.5 liter; f) 0.25 liter;
g) 0.125 liter.

Since each molecule of Water has 2 O atoms there are just as many water molecules as there were (diatomic) Oxygen molecules originally. Then the final volume of steam is the same as the original volume of Oxygen; i.e. one liter

[Alternatively, 4 Atoms of H in each H_4O_2 molecule is twice as many as in each original H_2 molecule. Then there are 1/2 as many H_4O_2 molecules as original H_2 molecules & the final volume of steam is 1/2 x initial volume of H_2

i.e. : (1 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 twice as great as earth's, and its length is shortened to 1.0 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%.

$T = 2\pi\sqrt{L/g}$

$T_P = 2\pi\sqrt{L_P/g_P}$ $\quad T_E = 2\pi\sqrt{L_E/g_E}$ $\quad \Rightarrow \frac{T_P}{T_E} = \sqrt{\frac{L_P \cdot g_E}{L_E\, g_P}}$

$T_P = (2.8)\sqrt{\frac{1}{2}\cdot\frac{1}{2}} = \frac{2.8}{2} = 1.4\,\text{sec}$

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