F07 Final Exam - Solutions

First Matching Table: **Questions 1 through 10: For each numbered question fill in on the corresponding line of your NCS answer sheet the circle under the letter of the single best answer.**

F	1. . The Linear Momenta of the particles of an isolated system	A. can become arbitrarily large, even while speeds remain below a finite limit.
D	2. Physical Dimensions	B. all eject heat in every cycle.
E	3.The Momentum of a particle	C. all depend upon the chosen frame of reference and not upon the physical surroundings.
G	4. Gravitational Fields	D. are always the same on both sides of a physical equation.
B	5. Heat Engines	E. always changes by the amount of the net impulse applied.
I	6.Kinetic Energies	F. all sum together to form a conserved quantity
J	7. Inertial Frames	G. are all interpreted in General Relativity as a curvature in space.
C	8. Inertial or Pseudo-Forces	H. all have the same physical dimension, L/T.
A	9. Relativistic Momenta	I. of all objects increase by the amount of the net work performed on them.
H	10. Velocities	J. are all equivalent because accelerations, not velocities, occur in the laws of physics.

Second Matching Table: **Questions 11 through 20**

E	11. Physical Processes	A. all exhibit (originally unexpected) wave interference patterns under appropriate circumstances.
J	12. Waves	B. all diminish with increasing momentum.
A	13. Electrons	C. all decrease with decreasing energy.
I	14. Atomic nuclei	D. all have electric charge, Q, only in integer multiples of e, the electron charge.
B	15. De Broglie wavelengths	E. all increase the entropy of the universe.
G	16. Photoelectrons	F. emit more blue light (compared to red) when T increases.
H	17. Average Molecular kinetic energies	G. all have kinetic energies limited by the frequency of the impinging light.
D	18. Charged microscopic oil drops	H. all increase with increasing temperature.
F	19. Hot Radiating Objects	I. all are immensely smaller in size and more massive than the electron cloud.
C	20. Frequencies of emitted photons	J. all combine by adding amplitudes, not intensities.

Continue Multiple Choice with Question No. 21 on next page....

21 **Exam Identification**: In the top line of this page this exam is identified as :

a

a.	**VERSION A**
b.	**VERSION B**

MULTIPLE CHOICE: Choose the one most nearly correct and complete answer and insert its letter into the corresponding line on your NCS answer sheet.

22. On a trip to Helena, you start your parked car, drive to Three Forks, stop for a one hour coffee break and arrive and park in Helena exactly two hours after leaving Bozeman. Since it is 100 miles to Helena, your average speed would be 50 mph. Which of the following statements about this trip is correct?
    - a. To average 50 mph the car must have reached or exceeded 100 mph at some point in the trip. T
    - b. The instantaneous speed was certainly equal to 50 mph at some point during this trip. T
    - c. It is possible to average 50 mph even if the speed is zero for more than one half of the trip duration. T
    - d. Since the car speeds up after each stop and slows down before each stop, it is in practice certain that the car traveled faster than 100 mph at some point in the trip T
    - e. The instantaneous speed was surely zero at some point during the trip. T
    - f. All of the above statements are correct.
    - g. None of the above statements is correct.

23. What average speed, most nearly, is required to run a five hour marathon (26 miles)? (1 mi. = 1.609 km.)
    - a. 0.0037 m/s
    - b. 0.023 m/s
    - c. 0.037 m/s
    - d. 0.23 m/s
    - e. 0.37m/s
    - f. 2.3 m/s
    - g. 3.7 m/s
    - h. None of the above answers is with 10% of the correct answer.

$$\frac{x_f - x_i}{t_f - t_i} = \bar{v} = \frac{26\ \cancel{mi}}{5\ \cancel{hr}} \times \frac{1\ \cancel{hr}}{60\times 60\ sec} \times \frac{1\ \cancel{km}}{0.625\ \cancel{mi}} \times \frac{10^3\ m}{\cancel{km}} = 2.31\ m/s \quad f$$

24. If a motorcycle requires 30 seconds to accelerate from 0 to 90 km per hour, its average acceleration is, most nearly,
    - a. 800 m/ sec^2
    - b. 80 m/ sec^2
    - c. 8 m/sec^2
    - d. 0.8 m/sec^2
    - e. 0.08 m/sec^2
    - f. None of the above is within 10% of the correct answer

$$\bar{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{(90-0)\ \cancel{km}}{30\ sec\text{-}\cancel{hr}} \times \frac{1\ \cancel{hr}}{3600\ sec} \times \frac{10^3\ m}{\cancel{km}} = 0.833\ m/sec^2 \quad d$$

25. In the strobe diagram below the ball is moving from right to left. Which statement best describes the motion? The ball is

...o o o o o o....

a. not accelerating. F
b. speeding up. F
c. slowing down. T
d. moving with a constant speed. F
e. none of the above. F

26. The motion of a block sliding down a frictionless ramp can be described as motion with

a. a constant speed, independent of the slope of the ramp. F
b. a constant speed that depends on the slope of the ramp. F
c. an acceleration which increases as the block continues sliding. F
d. a constant acceleration which is negative (i.e., slows the object down) due to the force of friction. F
e. a constant acceleration less than or equal to g= 10 m/s/s. T
f. None of the above.

$\frac{F}{m} = a = \frac{\cancel{mg}}{\cancel{m}} \sin\theta \leq g.$ (e)

27. If a ball is dropped from rest, it will fall 5 m during the first second. How far will it fall during the fourth second, most nearly ?

a. 15 m
b. 25 m
c. 35 m
d. 45 m
e. 75 m
f. None of the above is within 25% of the correct answer.

$x(t=4) - x(t=3) = D_{4th} = \frac{1}{2}g\cdot(16-9) = 35m$ (c)

using $x = \frac{1}{2}at^2$

28. The Center of Mass Point of a solid body

a. is certain definite fixed point in a coordinate system fixed to the body itself. T
b. moves as though all of the forces applied to the body were applied at its location. T
c. moves as though the entire mass of the body were concentrated at its location. T
d. may be located outside the physical extension of the body. T
e. None of the above answers (a through d) is true and correct. F
f. All of the above remarks (a through d) are true of the Center of Mass Point. T

29. You are applying a 600-newton force to a freezer full of chocolate chip ice cream in an attempt to move it across the basement. It will not budge. The weight of the freezer (including ice cream) is 1500 N. The coefficient of static friction, μ_{Static} is

a. greater than or equal to 0.4
b. greater than 0.4 but less than 0.8.
c equal to 0.4, exactly.
d. less than 0.4.
e less than 0.4 but greater than 0.25
f. None of the above completions yields a true statement.

$F_{static} = \mu_{Static}|N| = \mu_s W \geq F_{App}$

where $F_{App} = 600N$

$W = 1500N$

$\mu_s \geq \frac{600}{1500} = 0.40$

30. Which of the following is *not* a vector quantity?
a. mass S
b. kinetic energy S
c. potential energy S
d. rest energy S
e speed S
f. work S
g. None of the above items (a) through (f) is a vector quantity T
h. All of the items (a) through (f) are vector quantities. F

31. What acceleration, most nearly, is produced by an applied force of 75 N acting on a mass of 7 kg if its velocity is 20 m/s and the frictional force is 5 N?
a. 10 m/ s^2
b. 9 m/s^2
c. 8 m/s^2
d. 7 m/s^2
e. 6 m/s^2
f. None of the above is within 10% of the correct answer.

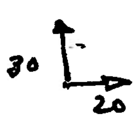
$F^{NET} = ma \Rightarrow a = \frac{75-5}{7} = 10\ m/sec^2$

32. A ball with a mass of 1kg is thrown vertically upward. What is the force on the ball just as it reaches the top of its path, most nearly ?
a. 10 N upward
b. 10 N downward
c. 20 N downward
d. 20 N upward
e. zero
f. None of the above is within 10% of the correct answer.

$F = -mg = -10\,N$: 10N downward

33. A ball falling from a great height will reach terminal speed when the __________ goes to zero.
a. velocity F
b. gravity force F
c. drag force F
d. weight F
e. speed F
f. acceleration T $\vec{a} = 0 \Rightarrow \vec{v} = \text{constant}$
g. None of the above insertions yields a true statement. F

34. A golf ball is hit with an initial vertical speed of 30 m/s and an initial horizontal speed of 20 m/s. How long will the ball remain in the air? (Neglect air resistance.)
a. 1 s
b. 2 s
c. 3 s
d. 4 s
e. 6 s
f. None of the above is within 10% of the correct answer.

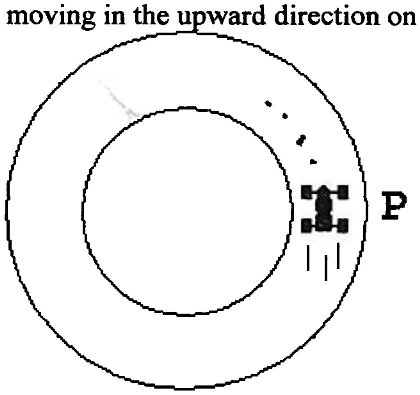


$v_y = v_{0_y} - gt = 0$ at top $\Rightarrow t^{TOP} = v_{0y}/g = \frac{30}{10} = 3\,sec$

& TIME in AIR $= 2 \cdot t^{TOP} = 6\,sec$

Figure 35-36

A 333 kg race car is moving counterclockwise on a circular path of radius 3000 m as shown in the diagram below. Suppose that at a certain instant when its speed is 140 m/s the car is at point P and moving in the upward direction on the page at a increasing speed .



35. Refer to **Figure 35-36** above. In what direction, precisely, does the net force point at the instant described?

a. ↑
b. ↓
c. →
d. ←
e. None of the above is precisely to direction in which the force points.

Direction of force is like F in diagram, because force must have both radial & forward tangential components

36. Suppose that the race track of Fig 35-36 is covered with a film of oil which reduces the coefficients, (both static and kinetic) of friction on the tires to zero and that the car is kept in its circular paths by cables attached to a post at the center of the track. What, most nearly, is the tension in the cable attached to the car in Fig.38 at the instant described above?

a. 2.2×10^2 N
b. 3.3×10^2 N
c. 2.2×10^3 N
d. 3.3×10^3 N
e. 2.2×10^4 N
f. 3.3×10^4 N
g. None of the above is within 10% of the correct answer.

$T = F_{centrip} = m\, v^2/R = \frac{(333)(140)^2}{3000} = 2175 \approx 2.2 \times 10^3$ c

37. A 2 kg ball is thrown straight down from the edge of a tall cliff with a speed of 20 m/s. At the same time a 1 kg ball is thrown straight up with the same speed. If the 1 kg ball travels up, stops, and then drops to the bottom of the cliff, which ball (if either) will be traveling faster when it reaches the ground below?

a. The 1kg ball, because its mass is smaller and it moves faster F
b. The 2kg ball, because its mass is larger and it accelerates at a greater rate. F
c. The 1 kg ball, but not for the reason given in (a) above. F
d. The 2 kg ball, but not for the reason given in (b) above F
e. The two balls will be traveling at the same speed when they hit. because after its rise to top and its return fall to cliff edge, 1kg ball has a downward speed of 20 m/s, the same as 2kg ball's initial speed, and it continues to accelerate downward at same rate as 2kg ball.
f. There is not enough information to say.

38. A baseball player throws a ball from left field toward home plate. Assume that you can neglect the effects of air resistance. At the instant the ball approaches home plate, the ball's acceleration

a. has the same magnitude as it had at the highest point of the trajectory. T: $\vec{a} = -\vec{g}$ = constant (a)
b. reaches its ~~minimal~~ value has the smallest value
c reaches its ~~maximal~~ value.
d. retains its constant value, zero. F
e. continues to increase until it hits the catcher's glove. F
f. There is not enough information to say. F

39. A mass, m = 0.900kg, hanging on a spring of spring constant , k= 10N/m, oscillates with a period, T= 1.88 s. If another oscillator has a mass twice as large and a spring constant half as large, its period will be (most nearly)?

a. 0.47 s
b. 0.94 s
c. 1.88 s
d. 3.76 s
e. 7.52 s
f. None of the above is within 10% of the correct answer.

$T_1 = 2\pi\sqrt{M_1/k_1} \rightarrow T_2 = 2\pi\sqrt{\frac{2M_1}{k_1/2}} = (2)\,2\pi\sqrt{M_1/k_1}$

$T_2 = 2(1.88) = 3.76$ sec (d)

40. An astronaut weighs 1000 N when measured on the surface of the earth. How large would the force of gravity on him be if he were in an earth satellite at an altitude equal to the earth's radius, most nearly ?

a. 60N
b. 110 N
c. 330 N
d. 250 N
e. 500 N
f. None of the above is correct within 10%.

At I

$Mg = 1000\,N \Rightarrow M = 100\,kg$; Also $F_G \propto \frac{1}{D^2}$

Then at altitude R_E, $D = 2R_E$,

& $F_G = Mg\left(\frac{R_E}{D}\right)^2 = \frac{Mg}{4} = \frac{1000}{4} = 250\,N$ (d)

41. A future space traveler, Skip Parsec, lands on the planet MSU3, which has twice the mass of Earth and twice its radius. If Skip weighs 400 Newtons on Earth's surface, how much does he weigh on MSU3's surface?

a. 1600 N
b. 800 N
c. 400 N
d. 200 N
e. 100N
f. 50 N
g. None of the above is correct within 10%.

$Mg_E = 400\,N$

$g_{MSU3} = g_E\left(\frac{R_E}{R_{MSU3}}\right)^2\left(\frac{M_{MSU3}}{M_E}\right)$

$= g_E \cdot \left(\frac{1}{2}\right)^2(2) = g_E/2$

$Mg_{MSU3} = Mg_E/2 = 400/2 = 200\,N$ (d)

42. The numerical value of G, the gravitational constant, was first estimated roughly

a. from careful studies of planetary motions F
b. by measuring the force between masses in the laboratory. F
c. from the law of universal gravitation and the value of the acceleration due to gravity. F
d. from the value of the moon's acceleration. F
e. from a very precise knowledge of the mass of the earth. F
f. by Newton from an educated guess about the earth's mass density. T
g. None of the above completions yields a true statement. F

43. Physical objects in an orbiting satellite such as SkyLab
a. have neither mass nor weight. F
b. have weight but no mass. F
c. have mass but feel no force due to gravity. F
d. are not accelerating. F
e. fall to the floor with an acceleration of 9.8 m/s/s. F
f. conform to all of the above statements (a) through (e). F
g. None of the above completions (a) through (f) yields a true statement.

44. Which of the following is true of the momenta of an 18-wheeler parked at the curb and a Volkswagen rolling down a hill?
a. The two momenta are equal.
b. The Volkswagen has the greater momentum
c. The 18-wheeler has the greater momentum. F $p_{18} = 0$
d. Either could have the greater momentum. F
e. The answer depends specifically upon the ratio of the masses. F
f. None of the above completions yields a true statement. F

45. The acceleration due to gravity on Titan, Saturn's largest moon, is about 0.7 m/s^2. What would a 60-kg scientific instrument weigh on Titan?
a. 4.2 N
b. 8.40 N
c. 42.0 N
d. 84 N
e. 420 N
f. 840 N
g. None of the above is within 10% of the correct answer.

$W = Mg_s = 60\,(0.7) = 42\,N$ c

46. If rockets (attached to the plane) are fired in the forward direction from a moving airplane, the velocity of the airplane will
a. decrease just enough to conserve the momentum of the plane plus rocket system . T
b. be unchanged, by conservation of momentum. F
c. increase just enough to conserve the momentum of the plane plus rocket system F
d. decrease, but not by an amount we can specify F
e. increase, but not by an amount that we can specify. F
f. None of the above completions yields a true statement. F

47. Sally is an astronaut who has a mass of 60 kg. Currently she is conducting experiments in a permanent space station that is orbiting the earth at an altitude equal to the earth's radius. What are Sally's mass and weight as measured in the space station?
a. 0.~~00~~ kg and 0 N, respectively.
b. 60 kg and 6~~00~~ N, respectively
c. 60 kg and 6~~0~~ N, respectively
d. 0~~00~~ kg and 6~~00~~ N, respectively
e. 60 kg is her mass, but her weight cannot be specified from the data given. F .
f. None of the above completions yields a true statement.

Mass $m = 60$ kg always!
& Weight $= W =$ NET FORCE on SCALE in satellite
$= F_G - F_{pseudo} \equiv 0 = W$ f is correct.

48. A red ball moving at 4 m/s toward the right has a head-on collision with stationary green ball of the same mass. Each of the following final velocity pairs satisfies the law of conservation of linear momentum. Which one also preserves kinetic energy? The red ball has a velocity of ___0___, while the green ball has a velocity of ___4___ to the right.

a. 2 m/s to the right … 2 m/s
b. 1 m/s to the right…..3 m/s
c. 1 m/s to the left …5 m/s
d. 2 m/s to the left …6 m/s
e. 3 m/s to the left….7 m/s
f. None of the above final situations has a final kinetic energy equal to the initial value.

49. A 5-kg toy car with a speed of 9 m/s collides head-on with a stationary 10-kg toy truck. After the collision, the cars are locked together with a speed of 3 m/s. How much kinetic energy is lost in the collision, most nearly ?

a. 25 J
b. 45 J
c. 65 J
d. 85 J
e. 105 J
f. 135 J.
g. None of the above is within 10% of the correct value

$(KE)_i = \frac{1}{2} 5 \cdot (9)^2 = 202.5\ J$

Cons. of p^{TOT} $5 \cdot 9 = 15 v_F \Rightarrow v_F = M_1 v_1/(M_1+M_2) = 3\ m/sec$ ✓

$(KE)_f = \frac{1}{2} 15 (9) = 67.5\ J$

$\Delta KE = 202.5 - 67.5 = 135\ J$ (f)

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

a. The heavier one.
b. The lighter one.
c. The one with the larger momentum.
d. The one with the smaller momentum
e. Both stop in the same distance.
f. It is not possible to say from the data given.

$F \Delta x = W = \Delta KE$ (Work Energy Thm)

$\Delta x_1 = \frac{\Delta(KE)_1}{F} \equiv \frac{\Delta(KE)_2}{F} = \Delta x_2$

Stopping distances are same

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

a. the heavier one.
b. the lighter one.
c. The one with the larger kinetic energy.
d. Both stop in the same time.
e. There is not enough information to say.

$F \Delta t = \Delta p$ (Impulse - Momentum Thm).

$\Delta t_1 = \frac{\Delta p_1}{F} \equiv \frac{\Delta p_2}{F} = \Delta t_2$

Stopping times are SAME $\Rightarrow$ Stopping distance is greater for the faster (i.e. lower mass) object (b)

52. Which of the following has the physical dimension of energy?

a. Newton-meter T (WORK)
b. kilowatt-sec T Power x time
c. joule T
d. kg-m^2/sec^2 T
e. All of the above have the physical dimension of energy. T
f. None of the units a) through d) has the dimension of a physical energy. F

(e)

53. Imagine riding in a glass-walled elevator that goes up the outside of a tall building at a constant speed of 20 meters per second. Assuming that you throw a ball downward at a speed of 20 m/sec as you pass a window, a person looking out the window will see the ball

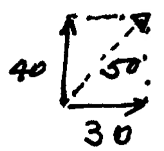
a. remain stationary. F
b. accelerate downward at 10 m/s^2, starting from rest. T
c. fall starting with an upward speed of 20 m/s. F
d. fall starting with an downward speed of 20 m/s. F
e. fall starting with a downward speed of 40 m/s. F
f. None of the above statements is true F

54. A person drops a ball in train traveling along a straight, horizontal track with a constant acceleration of 10 m/s^2 in the forward direction. What would the person in the station say about the horizontal forces acting on the ball?

a. There are no horizontal forces acting on the ball. T
b. There is a horizontal force acting forward of magnitude, g/2 F
c. There is a horizontal force acting backward of magnitude, g/2. F
d. There is a horizontal force, but its magnitude cannot be stated in terms of g. F
e. There is a horizontal force acting backward of magnitude, g. F
f. The person in the station could make none of the above statements. F

55. A rock is thrown horizontally at 40 m/s from the back of a flatbed truck that is moving with a constant velocity of 30 m/s. Relative to an observer on the ground, what is the horizontal speed of the rock when it is thrown in the sideward direction?

a. 10 m/s
b. 20 m/s
c. 30 m/s
d. 40 m/s
e. 50 m/s
f. 70 m/s
g. None of the above speeds is within 10 % of the correct answer.



56. A train is traveling along a straight, horizontal track with a constant acceleration in the forward direction. At the instant the speed is 50 mph, a ball is dropped by an observer in the train. An observer on the train determines that the horizontal speed of the ball during the fall is

a. constant and equal to 50 mph. F
b. decreasing. F
c. zero. F
d. increasing. T
e. None of the above.

57. An observer drops many different balls in a train traveling along a straight, horizontal track with a constant acceleration in the forward direction, and notes their trajectories and their masses What could the observer in the train infer about the horizontal force acting on the ball?

a. There is a horizontal force, but nothing is known about its origin. F
b. A physical horizontal force acts backward. F
c. A gravitation-like pseudo-force always proportional to the mass acts in the backward direction. T
d. There is a centrifugal force. F
e. None of the above is true about the observed horizontal force. F

58. While driving to the movies you decide to make a sharp right-hand turn to slide your date over towards you. (Assume that the seat is frictionless.) In your rest frame, your date experiences a net force to the left as he/she slides, while a person standing on the sidewalk says your date experiences
a. a net force to the right.
b. a net force to the left.
c. no net force. : Date continues in straight line motion as car accelerates right
d. a net force backward
e. a net force forward.
f. None of the above completions yields a correct statement.

59. What would an observer in an elevator measure for the magnitude of the free-fall acceleration near the surface of Earth if the elevator accelerates upward at 6 m/s^2?
a. 4 m/s^2
b. 6 m/s^2
c. 10 m/s^2
d. 14 m/s^2
e. 16 m/s^2 $= g + 6$
f. None of the above.

60. In his theory of special theory of relativity, Einstein
a. reaffirmed the Galilean principle of relativity. T
b. depended upon Maxwell's equations for electricity and magnetism. T
c. showed that the ether medium hypothesized for electromagnetic waves was unneeded. T
d. rejected the possibility of an absolute reference system. T
e. postulated that the speed of light was constant in vacuum T
f. All of the above statements (a) through (e) yield true statements about Einstein's Special Theory of Relativity. T
g. None of the above completions, (a) through (e) yields a true statement. F

61. On which of the following observations, (a) through (e), will two observers in different inertial systems agree about the results?
a. The simultaneity of events at separate locations. NOT
b. The rate at which one another's clocks run NOT
c. The lengths they measure along the direction of their relative travel NOT
d. The synchronization of their own clocks with the moving clocks of the other frame. NOT
e. The instantaneous velocity of a given object. NOT
f. The observers will agree on none of the items (a) through (e) above. TRUE
g. The observers will agree on all of items (a) through (e) above. F

62. A rocket ship is 300 m long when measured at rest. A stationery observer, O, who sees the rocket ship moving past at 99.9% of the speed of light measures its length by marking the location of its nose and its tail simultaneously and then measuring the distance between the two locations. A second observer, Õ, on the rocket ship watches the observer, O, measure the length of the ship. Afterwards, Õ criticizes O's measurement by saying

a. that he measured the length of O's meter stick and found that it was in fact shorter than a meter. Valid
b. that O did not actually measure position of the two ends of the ship at the same time, but that instead he first fixed the location of the front of the ship and then, afterwards, that of the back. Valid
c. that when O claimed to have insured that he was locating the front and back at the same time by firing light pulses which then arrived half way between at the same time, his light pulses were not in fact fired simultaneously. Valid
d. None of the above objections (a) through (c) above, is true and valid. F
e. All of the objections, (a) through (c) above, are true and valid

63. Einstein's Equivalence Principle is supported by the fact that

a. Light is observed to be deflected when passing massive objects, as he predicted. T
b. The gravitational mass in Newton's Law of Universal Gravitation and the inertial mass in Newton's Second Law have, within the diminishing experimental error, the same values. T
c. The inertial pseudo-force required to explain the physics in an accelerated frame is proportional to the gravitational mass, m, of the object observed. T
d No experiment has been devised which exhibits a measurable difference between a gravitational force and an acceleration of the local frame of reference. T
e In fact, none of the "facts" cited in (a) through (d) above actually supports the Principle of Equivalence. F
f. In fact, all of the facts cited in (a) through (d) above actually support the Principle of Equivalence. T

64. An electron is being accelerated by a constant force to a speed approaching the speed of light. Which of the following statements, (a) through (e), is **true**?

a. Its kinetic energy increases steadily. T $\Delta KE = W^{NET}$
b. Its relativistic momentum increases at a constant rate. T : $F = \Delta p_{REL}/\Delta t = const$
c. Its speed can approach, but not exceed, the speed of light. T: $p = \gamma m v \to \infty$ at $v = c$ & is never achievable.
d. Its total energy continually increases. $E^{TOT} = \gamma mc^2$: T: γ increases continually.
e. The power, or energy per unit time, required to accelerate approaches a constant T
f. None of the above statements (a) through (e) is true. F $P = \Delta W/\Delta t = \frac{F \cdot \Delta x}{\Delta t} \to F \cdot c = const.$
g. All of the statements (a) through (e) above are true. T

65. Superman wants to travel back to his native Krypton for a visit, a distance of $3X10^{14}$ meters. (It takes light 10^6 seconds to travel this distance.) If Superman can hold his breath for 10^5 s and travel at any speed less than $c = 3X10^8$ m/s, can he make it before he suffocates?

a. No, and he always falls far short of the trip distance.
b. No, but he always falls short by less than 10% of the trip distance.
c. Yes, but always just barely, with less than 1% of the trip distance to spare.
d. Yes, because he can reduce the contracted distance he travels to as small a value as he likes by setting his speed closer to that of light.
e. No, because for him his moving biological clock speeds up and gives him less time.
f. None of the above completions yields a true statement.

66. Which of the following expressions gives the relativistic kinetic energy of a moving object?
a. $E = mc^2$ REST
b. $E = \gamma mc^2$ TOTAL
c. $E = (\gamma-1)mc^2$ = (TOTAL - REST) ENERGY
d. $E = (mv^2)/2$ = NON RELATIVISTIC LIMIT of ©.
e. None of the above. F

67. If the inertial mass, m_I in Newton's II law and the gravitational mass m_G in Newton's law of gravitation were NOT the same for the same object, then
a. the form of Newton's law of universal gravitation would need to be modified. NOT
b. the form of Newton's second law would need to be modified. NOT
c. Einstein's prediction that the path of light is bent by gravitational fields would stand, since light is massless. FALSE: GRAVITY & LOCAL ACCELERATION would NOT be EQUIVALENT
d. An object with masses (m_I, m_G) would feel a gravitational force, $m_G g$, near the earth's surface equal in magnitude to its inertial pseudo-force, $-m_I g$, in a frame of reference accelerating at a constant rate, g, in some inertial frame. FALSE since $m_I \neq m_G$
e. All of the above statements are true.
f. None of the above statements is true

68. The law of definite volume proportions for gaseous reactants (all under the same standardized temperature and pressure conditions)
a. states that equal volumes of different gases always contain equal numbers of ~~atoms~~ particles. F
b. was first proposed on purely philosophical grounds F
c. follows automatically from the law of definite mass proportions F
d. summarizes the experimental fact that reactant gas volumes which combine completely to form compounds always have ratios equal to the ratios of small integers. T
e. None of the above completions (a) through (d) yields a true statement. F
f All of the above completions (a) through (d) yield true statements. F

69. Suppose that one mole of potassium sulfide (K_2S) molecules consists of 1 mole of sulfur (S) atoms(A=32) and 2 moles of potassium (K) atoms (A=39). If you combine 2 kg of sulfur with 1 kg of potassium to form potassium sulfide, how many moles of potassium sulfide can you make, approximately?
a. 39
b. 32
c. 31.
d. 26
e. 13
f. None of the above is within 10% of the correct answer.

1 mole (N_A) of K_2S molecules need (2·39) gm K & 32 gm S.

Then 1 kg K can make $\left(\frac{10^3}{78}\right)\frac{gm}{gm}$ = 12.8 moles of K_2S

& 12.8 moles of K_2S require 409.6 g of S.

Therefore make 12.8 moles K_2S (e)
& K is exhausted w S left over.

70. Suppose, hypothetically, that in question 69 above, both of the reactants, K and S, were diatomic gases, and suppose that 2 liters of potassium combines entirely with 1 liter of sulfur to form potassium sulfide, also a gas. Then, if the chemical formula for potassium sulfide were K_8S_4, how many liters of K_8S_4 would be produced, most nearly?

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

if $1\ell\ S_2$ could make 2ℓ of S atoms or $\frac{2\ell}{4}$ of K_8S_4 molecules
since each K_8S_4 has 4 S atoms: $\frac{2\ell}{4} = \frac{1}{2}\ell$ (d)

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

a. particles rebound elastically when they collide with the container wall. T
b. particles may vibrate, but only if they are diatomic molecules. F NO INTERNAL PARTICLE STRUCTURE!
c. particles are indestructible and do not combine with one another. T
d. particles do not interact except when they collide. T
e. particles travel in straight lines between collisions. T
f. All of the above properties (a) through (e) are properties of our ideal gas. F
g. In fact, none of the above properties, (a) through (e), is a property of our ideal gas. F

72. Which of the following doubles with a doubling of the absolute temperature of an ideal gas?

a. average momentum X
b. average kinetic energy T
c. average velocity X
d. average mass X
e. Average speed X
f All of the quantities, (a) through (d) above, double with the absolute temperature. X
g None of the quantities, (a) through (d) above, doubles with the absolute temperature X

73. Which of the following doubles with a doubling of the Celsius temperature of an ideal gas?

a. average momentum
b. average kinetic energy
c. average velocity
d. product of pressure and volume
e. All of the quantities, (a) through (d) above, double with the Celsius temperature.
f. None of the quantities, (a) through (d) above, doubles with the Celsius temperature

NONE! $T_{ABSOLUTE}$ not T_C occurs in EQUI-PARTITION RESULT $\langle KE \rangle_i = \frac{3}{2} kT_A$ (f)

74. The pressure in a rigid container filled with gas increases when it is heated because

a. the walls must do more work on the gas as T increases. F
b. the volume of the gas increases with temperature. F (rigid!)
c. the number of gas particles increases with temperature. F
d. the walls must exert a larger impulse to turn back the particles T $F\Delta t = \Delta p$
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

75. Joule's experiments with hanging weights turning paddle wheels in water
a. showed that mechanical energy was converted to heat by viscous forces. T
b. showed that 4.2 joules of work are equivalent to 1 calorie of heat. T
c. fixed the ratio between the Joule and the (independently defined) calorie. T
d. led to a generalization of the law of conservation of mechanical energy. T
e. None of the above completions, (a) through (d) provides a true statement. F
f. All of the above completions, (a) through (d) provide a true statements. T

76. Which of the following completions, (a) through (d) below, leads to a **true** statement? The first law of thermodynamics
a guarantees that if work is done on a system in some process and no net heat is ejected, the internal energy of the system must increase. T
b. is a restatement of the law of conservation of energy to include thermal energy. T
c. allows the possibility that heat can be completely converted into work. T
d. treats heat as another form of energy. T
e. All of the above statements (a) through (d) are true of the first law: None is false. T
f. None of the above statements (a) through (d) is true of the first law: All are false. F

77. If during some process a system has no change in internal energy, we can say that
a. the system ejected no heat. F
b. no work was done on the system. F
c. the net amount of work done by the system was equal to zero. F
d. the net heat received equals the net work performed. T
e. None of the above assertions can be made on the basis of this statement. F
f. All of the above assertions are guaranteed by the condition stated. F

78. Why are steam burns more damaging medically that hot water burns?
a. Because steam has a greater specific heat than water. F
b. Because it takes 540 times more calories to convert a gram of water to steam than to cool a gram of water by 1° C. T
c. Because steam tends to stick to the skin. F
d. Because water tends to flow along and away from the skin. F
e. Because water has a high latent heat of fusion F
f. Because water has a relatively higher specific heat than steam. F
g. None of the above causes steam burns to be worse than hot water burns. F

79. In our laboratory measurement of c_{CU}, the specific heat of copper, a hot copper cylinder is immersed in a cup of cold water, and allowed to come to equilibrium. During this process heat transfer into or out the equilibrating (copper + water) system may cause the result to be erroneous. Under which of the following circumstances would the heat transfer error tend to reduce the value of c_{CU}, the measured specific heat of Cu?
a. Some heat flows into the system, but the heat outflow is not known.
b. Some heat flows out of the system, but the heat inflow is not known.
c. Heat flows into and out of the system, but on balance more heat flows in.
d. Heat flows into and out of the system, but on balance more heat flows out.
e. None of the above heat flows (a) through (d) ~~would reduce the~~ measured value of c_{CU}

← Because loss of heat lowers final Temp & thus makes heat supplied by Cu appear smaller than its actual value.

80. The first law of thermodynamics, like the law of conservation of momentum and other conservation laws, is valid only

a. if no work is done on the system. F
b. when there is no friction. F
c. when all of the forces acting are conservative. F
d. when the system considered is isolated so that no energy transfers occur into or out of it. T
e. if the third law of thermodynamics is valid. F
f All of the above completions (a) through (e) yield a true statements. F
g. None of the above completions (a) through (e) yields a true statement. F

81. The second law of thermodynamics says

a. that the energy of an isolated system is conserved. F
b. that the entropy of the earth can never decrease. F
c. that it is impossible to reach the absolute zero of temperature. F
d. that it is impossible to build a heat engine that does mechanical work equal to the heat energy provided by its fuel. T
e. that two objects which are both in thermal equilibrium with the same third object are also in thermal equilibrium with one another. F
f. None of the above. F

82. Which of the following statements conflicts with the second law of thermodynamics?

a. Heat naturally flows from hot objects to cold objects. NO CONFLICT
b. No engine can transform all of its heat input into mechanical work. N.C.
c. The entropy of an isolated system can never decrease. N.C
d. Perpetual motion machines are not possible. N.C
e. No heat engine can be ~~less~~ efficient than the Carnot engine with the same maximum and minimum temperatures F : more efficient
f. Every heat engine must exhaust heat. N.C
g. None of the above contradicts the second law. F

83. 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 420 J/min. By how much does the internal energy of the room outside the refrigerated chamber change, most nearly, in each minute?

$Q^{IN} + W^{IN} = \Delta U$

$100\ \text{cal/min} + 420\ \text{J/min} = \Delta U$

$(100 + 100) = 200\ \text{cal/min}$

a. It ~~decreases~~ by 100 cal/min.
b It ~~decreases~~ by 200 cal/min
c. It ~~decreases~~ by 520 cal/min.
d. It ~~stays~~ the same.
e. It ~~increases~~ by 520 cal/min
f. It increases by 200 cal/min. ✓
g. None of the above is within 10% of the correct answer.

84. An ideal heat engine has a theoretical efficiency of 20% and an exhaust temperature of 127° C. What is its input temperature, most nearly ?

a. 230° C
b. 480° C
c. 600° C
d. 750° C
e. None of the above is within 10% of the correct answer

$\eta_{CARNOT} = 1 - T_C/T_H \Longleftrightarrow 0.20 = 1 - \frac{400}{T_H}$

w. $T_C = 127°C = 400K$

$\frac{400}{T_H} = 1 - 0.2 = 0.80$

$T_H = 500K$
-273
$227°C \approx 230°C$ ⓐ

85. 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 26°C and the temperature at 50 m below the surface is 14° 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. 0.02 J
c. 0.03 J
d. 0.04 J
e. 0.05 J
f. None of the above is within ±10% of the correct answer.

$\eta^{MAX}_{ACTUAL} = \eta_{CARNOT} = 1 - T_C/T_H = 1 - 297/299 = 0.040$

using $\begin{cases} 26°C = 299K \\ 14°C = 297K \end{cases}$

& $\eta = \frac{W^{OUT}}{Q^{IN}} \leq 0.04$ ⓓ

86. A ringing bell is inserted into a large glass of water. The bell and the water are initially at the same temperature and the container is insulated and isolated from their surroundings. Eventually the bell stops vibrating comes to rest, as does the water. Which of the following statements is TRUE?

a. The mechanical energy of the bell has been completely converted into internal energy of the combined system. T
b. The final temperature of the combined system is greater than the initial temperature. T
c. The entropy of the combined system has increased. T
d. The total energy of the system is the same at the end as at the beginning. T
e. All of the above statements (a) through (d) are true. T

87. A heat engine exhausts 1200 J of heat for every 1600 J of heat which it takes in. What is its efficiency?

a. 25%
b. 33%
c. 50%
d. 67%
e. 75%
f. None of the above is within 10% of the correct answer.

$\eta = \frac{W^{OUT}}{Q^{IN}} = \frac{1600-1200}{1600} = \frac{1}{4} = 25\%$ ⓐ

88. Which of the following did **NOT** help move physics towards quantization ?

a. A Thomson plum pudding atom which backscattered He++ (alpha) particles.
b. A Rutherford atom which does not collapse spontaneously.
c. A Black Body intensity spectrum which goes to zero, not infinity, at zero wave length.
d. Photoelectrons with maximal energies fixed by the light frequency.
e. Discrete emission and absorption frequencies for elements.
f. In fact, all of the items, (a) through (e) above, pushed physics towards quantization, and none did **NOT**.

89. The efficiency of an ideal heat engine can be improved by increasing the input temperature and decreasing 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 temperature.

$\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{T_{out}}{T_{IN}}$ (b)

90. How much work per second (power) is required by a refrigerator that takes 800 J of thermal energy from a cold region each second and exhausts 2800 J each second to a hot region? (1W = 1 J/sec)

a. 2000 W
b. 1200 W
c. 800 W
d. 400 W
e. None of the above is within 10% of the correct answer.

$Q + W = \Delta U$ per second
$800 + W = 2800\,J$
$W = 2000\,W$

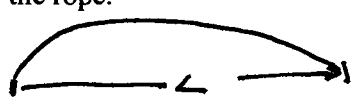
91. Which of the following sets of parameters all affect the period of a pendulum? (M = Mass, L = Length, and g = acceleration due to gravity)

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.

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

92. The fundamental wavelength for standing waves on a rope fixed at both ends is twice the length of the rope.

a. four times
b. two times
c. the same as
d. one-half
e. one-fourth
f. None of the above



$\frac{\lambda}{2} = L \Rightarrow \lambda = 2L$

93. If a certain ultra-violet light has a frequency of 10^{16} Hz, its wave length is, most nearly. (1 Hz = 1 cycle/sec, and c = $3X10^{8}$ m/sec.)

a. $1 X 10^{-7}$ m
b. $3 X 10^{-7}$ m
c. $1 X 10^{-8}$ m
d. $3 X 10^{-8}$ m
e. $3 X 10^{-24}$ m
f. None of the above is within 10% of the correct wavelength.

$f \cdot \lambda = c$
$\lambda = \frac{3\times10^{8}\,m/s}{10^{16}/s} = 3\times10^{-8}\,m$

94. What is the frequency of the earth's rotation about the sun, most nearly?
(1Hz = 1cycle/sec)

$\frac{1\,cycle}{year} \times \frac{1\,year}{365\,days} \times \frac{1\,day}{24\,hr} \times \frac{1\,hr}{60 \times 60\,sec} = \frac{3.27 \times 10^{-8}}{sec}$ (f)

a. 4×10^{-2} Hz
b 8×10^{-2} Hz
c. 7×10^{-4} Hz
d. 1×10^{-5} Hz
e. 2×10^{-6} Hz
f. 3×10^{-8} Hz
g. None of the above is within 20%of the correct answer.

95. The transverse wave speed along a string of length 0.30m fixed at both ends is 150 m/s. What is the frequency of the third standing wave on this string?

$v = f \cdot \lambda$ & $\frac{3\lambda_3}{2} = L \Rightarrow f_3 = \frac{v}{(2L/3)} = \frac{(150)(3)}{(2)(0.3)} = \frac{750}{sec}$

$L = 3/2\,\lambda_3$

(a)

a. 750 Hz
b. 625 Hz
c. 500 Hz
d. 375 Hz
e. 250 Hz
f None of the above is correct within 10%.

96. The periodic table arranges the elements according to
a. the order in which they were discovered. F
b. their chemical properties. T
c. their relative abundances. F
d. alphabetical order of their names. F
e. None of the above. F

97. Thomson's plum pudding model of the atom was abandoned because.
a. of the cathode ray studies which discovered electrons. F
b. of the large (compared with the H+ ion) charge to mass ratio of the electron. F
c. the electron charge was shown to be quantized in integer units of the smallest charge. F
d. the atom had to be neutrally charged electrically. F
e. alpha particles sometimes back scattered. TRUE: RUTHERFORD
f. All of the above were reasons for abandoning the Thomson model. F

98. Cl;assical theory predicted that Rutherford's atom should be unstable (because the electrons should spiral into the nucleus) in very short time periods. What causes this classical instability in Rutherford's model?
a. The positive charge in the nucleus was too strong for the electrons to remain in distant orbits. F
b. The attractive force between the positive nucleus and the negative electrons would pull them together. F
c. An accelerating, such as one in uniform circular motion, charge must radiate energy. T
d. Circular orbits are unstable for an attractive inverse square force. F
e. All of the above. F
f. None of the above. F

99. 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 depends on the frequency of the light. T
d. Are referred to as cathode rays. F
e All of the above. F
f. None of the above. F

100. 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. average speed F
d. average kinetic energy F
e. All of the above quantities increase with intensity. F
f. None of the above completions yields a true statement. F

101. Bohr gave the following argument why the electron in the hydrogen atom existing only in certain discrete energy levels
a. This agrees with the Newtonian mechanics of planet-like motion.
b. This agrees with Maxwell's equations.
c. This was implied by the Rutherford atom
d. All of the above were cited by Bohr.
e. None of the above arguments was presented by Bohr.

102. Which of the following is NOT a feature of the Bohr model of the atom?
a. a quantized electron angular momentum, L=r*p. ✓
b. electrons spiraling between allowed orbits in "quantum jumps". e's are not allowed to exist outside of quantized Bohr orbits.
c. quantized energy levels ✓
d. accelerating electrons that do not radiate. ✓
e. photons emitted when electrons jump from one orbit to another. ✓
f. All of the above are features of the Bohr model. F
g. None of the features (a) through (e) is a feature of the Bohr model. F

103. What is the de Broglie wavelength of a baseball (mass = 0.5 kg) traveling at 100 mph (44.4 m/sec), most nearly? (Planck's constant is h = 6.63×10^{-34} J·s.)
a. 2×10^{-34} m
b. 3×10^{-34} m
c. 2×10^{-35} m
d. 3×10^{-35} m
e. None of the above is correct within 10%.

$$\lambda_{DeB} = h/p = \frac{6.63 \times 10^{-34}}{(0.5)(44.4)} \frac{kg\, m^2/s}{(kg)\, m/s} = 0.299 \times 10^{-34}\, m \approx 3 \times 10^{-35}\, m$$

d

Note: The following (last seventeen) problems may require somewhat more calculation than the average. You may wish to sequence your work accordingly

104. A photon has an energy of 6.63×10^{-24} J. What is its wavelength?
(Planck's constant is $h = 6.63 \times 10^{-34}$ J·s.)

a. 3×10^{-4} m
b. 3×10^{-2} m
c. 3 m
d. 3×10^{2} m
e. 3×10^{4} m
f. None of the above is correct within 10%.

$E = hf \Rightarrow f = \frac{6.63\times10^{-24}}{6.63\times10^{-34}} = 10^{10}/sec.$

$\lambda = c/f = \frac{3\times10^{8} m/sec}{10^{10}/sec} = 3\times10^{-2} m$ (b)

105. A 40-kg crate is being pushed across a horizontal floor by a horizontal force of 240 N. If the coefficient of sliding friction is 0.4, what is the acceleration of the crate, most nearly?

a. zero
b. 1 m/s^2
c. 2 m/s^2
d. 3 m/s^2
e. 4 m/s^2
f. 5 m/s^2
g. 6 m/s^2
h. None of the above is within 10 % of the correct answer.

$F_f = \mu |N| = \mu |W| = \mu \cdot 40 \cdot g = 160\ N$

$F_{NET} = 240 - 160 = 80N = ma$

$\frac{80}{40} = a = 2\ m/sec$ (c)

106. Consider a very high waterfall. If the water is flowing horizontally at a speed of 3m/s as it passes over the lip of the falls, and hits the pool below at a point 30 m out from the lip, what is the height of the falls above the pool, most nearly?

a. 30m
b. 500 m
c. 1000 m
d. 1500 m
e. 2000 m
f. None of the above is within 10% of the correct answer.

$x(t) = v_{0x} t = 30\,m \Rightarrow t = 30/3 = 10\,sec$ = time to fall

$d = \frac{1}{2} g t^2 = \frac{1}{2} \cdot 10 \cdot (10)^2 = 500\,m$ (b)

107. A man stands on a large platform merry-go-round which is rotating at a constant angular speed, ω = 0.408 radians/second. The normal force between his shoes and the platform is equal to his weight, 500 N, and the coefficient of static friction is $\mu_{STATIC} = 0.100$. How far from the center can he stand without sliding off the platform, most nearly ?

a. 1 m
b. 2 m
c. 3 m
d. 4 m
e. 5 m
f. 6 m
g. None of the above is within 10% of the correct answer.

$F_f^{MAX} = \mu |N| = (0.1)(500\,N) = 50\,N$ = MAX force of static friction

TO AVOID SLIDING $F_f^{MAX} > F_{centrip} = MR\omega^2$

$50 > 50 R (0.408)^2$

$\frac{50}{(50)(0.1665)} > R$

$6.0\,m > R$ (f)

108. Suppose Newton lived on another planet and thought of launching his apple horizontally at such a speed as to make it travel around that planet (presumed smooth for the present discussion) in a circle at fixed height. What horizontal speed, most nearly, must it have to have to stay at the same small height above the planet's surface? (Take the radius of the planet to be 1.25X10^5 m, and the planet's gravitational acceleration to be 8 m/s^2.)

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

$Mg_P = F_G = Mv^2/R$ to have circular orbit

i.e. $v^2 = R \cdot \frac{\cancel{M}g_P}{\cancel{M}} \Rightarrow v = \sqrt{(1.25\times10^5)8} = \sqrt{10^6} = 10^3$ m/sec

c

109. An 800-kg frictionless roller coaster starts from rest at a height of 24 m. It travels 500 m under a frictional force of 168 N to the crest of a hill that is 12 m high. What is its kinetic energy at the top of the 12 m hill, most nearly? (1 kJ = 10^3 J.)

a. 0 kJ
b. 12 kJ
c. 24 kJ
d. 48 kJ
e. 96 kJ
f. 192 kJ
g. None of the above is within 10% of the correct answer.

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

$Mgh_i - (500)(168) = Mgh_f + (KE)_f$

$(800)(10)(24 - 12) - (500)(168) = (KE)_f = \quad = (KE)_{final}$ b

$96{,}000 - 84{,}000 = 12{,}000$ J

110. A block weighing 30 N is falling with a kinetic energy of 25 J at time, $t_1 = 0$, when a constant upward force sufficient to provide a net upward force of 6 N is applied. At a particular later time, t = t_2 the block has been lifted 15 m above the point where it was at t= 0. What is its kinetic energy at time t_2, most nearly?

a. 145 J
b. 115 J
c. 85 J
d. 55 J
e 30 J
f. 25 J
g. 0 J
h. None of the above is within 10% of the correct answer.

$W_{NET} = \Delta(KE) = (KE)_f - (KE)_i$

$(6N)(15m) + (25J) = (KE)_f$

(b) $115 J = (KE)_f$

111. What average power is required to accelerate a 1180-kg truck from rest to 9 m/s in 8 s, most nearly? (1 kW = 1000 watts = 1000 J/sec.)

a. 0 kW
b. 6 kW
c. 12 kW
d. 18 kW
e 24 kW
f. None of the above is within 10% of the correct answer.

$\frac{\Delta W}{\Delta t} = \frac{\Delta(KE)}{\Delta t} = \frac{\frac{1}{2} M v_f^2}{(8-0)} = \frac{1}{2}\frac{(1180)(81)}{8} = 5974 \frac{J}{sec} \approx 6000 W$ (b)

112. A child who weighs 500 N when at rest is riding in the rotating cylinder ride. The cylinder rotates fast enough to create a horizontal inertial (centrifugal) pseudo-force of magnitude 2000 N acting upon him in the rotating frame. What is the smallest value of the coefficient of friction between the rider and the wall of the cylinder which suffices to keep him from falling when the floor is removed, most nearly? The coefficient μ must be greater than or equal to

a. 0.05
b. 0.15 N
c. 0.25 N
d. 0.35 N
e. 0.45 N
f. 0.55 N
g. None of the above is within 10% of the correct answer.

$\mu |N| = \mu F_{centrifugal} > Mg = 500\ N$

$\mu > \frac{500}{2000} = 0.25$ c

113. A relativistic train is traveling along a straight, horizontal track at a constant speed, $v = 0.995c = (1\text{-}5 \times 10^{-5})c$. 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;

$\Delta t = \gamma \Delta t'$

$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} = \frac{1}{\sqrt{(1-v/c)(1+v/c)}} \approx \frac{1}{\sqrt{2(1-v/c)}}$

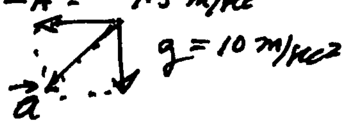
i.e. $\gamma = \frac{1}{\sqrt{2(5 \times 10^{-5})}} = \frac{1}{\sqrt{10^{-4}}} = 10^2$

$\Delta t = 10^2$ sec e

114. 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 of __________ m/s^2, most nearly.

a. 2.5 m/s^2.
b. 5.0 m/s^2.
c. 7.5 m/s^2.
d. 10.0 m/s^2.
e. 12.5 m/s^2.
f. 15.0 m/s^2.
g. 17.5 m/s^2.
h. None of the above is within 10% of the correct answer.

$-A = -7.5\ m/sec^2$ $\qquad |\vec{a}| = \sqrt{10^2+(7.5)^2} = 12.5\ m/sec^2$



e

115. 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 several chemical formulas which are consistent with this ratio (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) 2 liters;
d) 1 liter;
e) 0.5 liter;
f) 0.67 liter;
g) 0.33 liter;
h) 0.16 liter
i) None of the volumes above is within 10% of the correct volume for H_6O_3.

Each liter of H_6O_3 "Steam" has 3 x as many H atoms as one liter of H_2. Therefore the volume of H_6O_3 must be 1/3 x Volume of H_2 = 2/3 l

116. A super-train is traveling along a straight, horizontal track at a constant speed, V=0.9c. It fires a super-rocket in the forward direction with a speed , v'=0.85c. (Recall that, relativistically, v =(v'+V)/(1+Vv'/c^2).) An observer in the train station will measures the speed of the rocket, most nearly, to be

a. 1.750 c
b 1.850 c
c. 1.000 c.
d. 0.996 c
e. 0.991 c
f. 0.986 c
g. 0.90 c
h. 0.85 c
i. 0.050 c
j. None of the above is correct within 0.002c.

$$v = \frac{(0.9 + 0.85)c}{[1 + (0.9)(0.85)]} = 0.9915c \quad e$$

117. 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, will its volume be 10^6 liters under 10 atmospheres of pressure?

a. 30,000°C
b. 27,000°C
c. 24,000°C
d. 21,000°C
e. 18,000°C
f. 15,000°C
g. 12,000°C
h. None of the above is within 10% of the correct Celsius temperature

$T_i = 27°C = 300\,K$; $T_f = ?$

$$\left.\begin{aligned} P_i V_i &= cT_i \\ P_f V_f &= cT_f \end{aligned}\right\} \Rightarrow \left(\frac{P_i}{P_f}\right)\left(\frac{V_i}{V_f}\right) = \frac{T_i}{T_f} = \left(\frac{1}{10}\right)\left(\frac{10^5}{10^6}\right)$$

i.e. $T_f = 100 T_i = 30{,}000\,K = 29{,}727°C$

$\approx 30{,}000°C$ a

well within 10%

118. A heat engine takes in 1200 J of heat energy at 1000 K and exhausts 900 J at 300 K. What is the theoretical maximum efficiency (i.e., the Carnot efficiency) for this engine, and what is its actual efficiency, respectively ?

a. ~~30~~% and ~~75~~%, respectively.
b. ~~30~~% and ~~70~~%, respectively.
c. ~~30~~% and 25% respectively.
d 70% and ~~75~~%, respectively
e. 70% and ~~70~~%, respectively.
f. 70% and 25%, respectively.
g. None of the above gives both efficiencies correctly within 10%.

$\eta_{CARNOT} = 1 - 300/1000 = 0.7 = 70\%$

$\eta_{ACTUAL} = \frac{W}{Q_{IN}} = \frac{1200-900}{1200} = \frac{1}{4} = 25\%$

(f)

119. The energy levels of the Hydrogen atom are correctly given by the formula of the Bohr model; as follows: $E_n = -13.6/n^2$, where n = 1, 2, 3,...gives the lowest orbits. (The energy units are electron Volts: $1\text{eV} = 1.6 \times 10^{-19}$ J.) Calculate the energy emitted when an electron jumps from the fourth Bohr orbit to the first (n=1) orbit.

a 13.6 eV
b. 12.7 eV
c. 10.2 eV
d. 3.4 eV
e. 0.85 eV
f. None of the above is correct within 10%.

$\Delta E_{4\to1} = E_4 - E_1 = 13.6\left(\frac{1}{1} - \frac{1}{16}\right) eV = 12.75 eV$ (b)

120. A certain shortwave antenna transmits electromagnetic waves of 1 m wavelength. What is the energy of one of its emitted photons, most nearly? (Planck's constant is h = 6.63 X 10^{-34} J·s.)

a. 10^{-24} J
b. 2 x 10^{-24}J
c. 10^{-25} J
d. 2 X 10^{-25} J
e. 10^{-26} J
f. 2 X 10^{-26} J
g. None of the above is correct within 10%.

$E = hf = \left(\frac{3\times10^{8}}{s}\right)\times(6.63\times10^{-34}\,J\cdot s)$

$f = c/\lambda = \frac{3\times10^{8}}{1}$ Hz

$E = 19.89\times10^{-26}$

$\approx 2\times10^{-25}$ d

End of FINAL EXAM F07