Physics 117 EXAM II Fall 2005: Detailed Solutions

Multiple Choice

Insert the letter of the single choice that best completes the statement or most nearly answers the question into the corresponding line on your NCS answer sheet..

1. Which of the following statements about Venus is correct?
   a. Venus has a constant velocity. ✗
   b. There is no net force acting on Venus. ✗
   c. The sun exerts a stronger force on Venus than Venus exerts on the sun. ✗
   d. Venus is driven along its orbit by magnetic forces. ✗
   (e.) Venus is always being accelerated ✓
   f. None of the above is true. ✗

2. Which of the following statements about the moon is most correct?
   (a.) The acceleration of the moon due to earth's gravitational attraction is greater than the earth's acceleration due to the moon's attraction, because its mass is smaller & the forces are equal.
   b. The earth's gravitational pull on the moon exceeds the moon's gravitational pull on earth. ✗
   c. The net force acting on the moon is due entirely to the earth's gravitational attraction. ✗ (sun etc.)
   d. Given that its orbital speed is constant, the moon is not accelerating. ✗
   e. The moon's acceleration due to the earth's gravitational attraction is equal to g/60, ✗ (actually $= g/(60)^2$) because the moon is 60 earth radii away from the earth. ($g = 9.8m/s^2$.)
   f. None of the above statements is true. ✗

3. What is the force of earth's gravity upon a 1 kg mass located 3.16 earth radii from the center, most nearly?
   a. 3.2 N
   (b.) 1 N ✓
   c. 0.32 N
   d. 0.1 N
   e. 0.033 N
   f. 0.01 N
   g. None of the above

$$F_G = mg \times \frac{1}{(3.16)^2} = \frac{1 \cdot 10}{9.98} \approx 1 \frac{kg\,m}{sec^2} = 1N$$

OR IN MORE DETAIL

$$F = G\frac{M_E m}{(D^2)} = \left\{\frac{GM_E m}{(R_E)^2}\right\}\frac{R_E^2}{D^2} = \{mg\}\left\{\left(\frac{1}{3.16}\right)^2\right\}$$

... Since $g = G\frac{M_E}{(R_E)^2}$ & $D = 3.16 R_E$

4. How large is the acceleration of a 5 kg weight due to earth's gravity when it floating freely in an earth satellite at an height of 5.32 earth radii above the surface of the earth?
   a. 10 m/s/s
   b. 5 m/s/s
   c. 2.5 m/s/s
   d. 0.5 m/s/s
   (e.) 0.25 m/s/s ✓
   f. None of the above is correct within 10%.

$$a = \frac{F}{m} = \frac{GM_E m}{(6.32)^2(R_E)^2}\cdot\frac{1}{m} = \frac{g}{(6.32)^2} = \frac{10}{40} \approx 0.25$$

Since $D = R_E + h = (1 + 5.32)R_E = 6.32 R_E$.

5. If you quadruple the length of the edge of a cube, its surface area increases by what factor?
   a. 1/16
   b. 1/4
   c. 1
   d. 4
   (e.) 16 ✓
   f. 64
   g. None of the above.

$A \propto L^2$: factor is $(4)^2 = 16$

6. The law of universal gravitation states that $F = GMm/r^2$. We frequently used the form $F = mg$ when we studied projectile motion. Which of the following justifies that use?
   a. The first form is not valid for projectile motion. X
   b. The first form does not work for single projectile because it requires two masses. X
   c. The first form is not valid near the surface of the earth. X
   d. The second form is simpler and therefore preferable to the first. X
   (e) The second form is a good approximation to the first for objects close to the earth's surface. ✓
   f. None of the above is a valid and true reason for using the second form. X

7. During the Apollo flights to the moon a well-known TV newscaster made the following Statement: "The Apollo space craft is now leaving the gravitational force of the earth." This statement is incorrect. He should have said that the space craft
   a. was now being attracted only by the moon. X
   b. was now being attracted only by the sun X
   c. was now attracted more by the sun than by the earth. X
   d. was now in a region of space where there no gravitational forces act upon it. X
   e. Was now being attracted more strongly by the earth than by the moon. X
   (f.) None of the above completions yields a valid statement ✓

8. The numerical value of G, the gravitational constant measured by Cavendish could in principle be checked against
   a. a calculation based upon detailed knowledge of the earth's mass density and volume Y
   b. a calculation based upon the value of the moon's acceleration due to earth's gravity, and independent knowledge of the mass of the earth. Y
   c. the perturbation of some planet's orbital trajectory due to a close passage of another planet, provided one knew their masses independently. Y
   d. the measured gravitational force between masses in the laboratory. Y
   (e.) All of the above checks are possible in principle. ✓
   f. None of the above completions provides a true statement. X

9. Which of the following would not cause even a slight increase in the gravitational force on an object near the surface of the earth?
   a. A high density ore deposit just under the surface — causes increase : reject
   b. a lower elevation — " "
   c. an increase in the object's mass — " "
   d. a downward velocity (as time progresses) — " "
   (e.) None of the above answers is correct. In fact, all of the above would cause at least a slight increase in the gravitational force on the object. ✓

10. In an orbiting satellite such as SkyLab, a physical object of mass = m
    a. has mass = m, and weight =mg. ($g = 9.8 m/s^2$.) X
    b. has mass but feels no force due to gravity. X
    c. has neither mass nor weight. X
    d. falls to the floor with an acceleration of 9.8 m/s/s. X
    e. conforms to all of the above statements. X
    (f.) conforms to none of the above statements. ✓

11. Geosynchronous communications satellites orbit the earth once each
    a. year ✗
    b. month ✗
    c. lunar month (28.3 days) ✗
    d. week ✗
    (e) day ✓
    f. In fact they don't orbit the earth at all; they just stay in one place ✗
    g. None of the above. ✗

12. Because the moon rotates about the earth (about once every 28.3 days) in the same direction that the earth rotates about its axis, there will occur on earth during some, but not most, 24 hour intervals,
    a. one high tide and one low tide; ✗ NEVER
    (b.) one high tide and two low tides, or two high tides and one low tide; ✓
    c. two high tides and three low tides, or three high tides and two low tides ✗ NEVER
    d. two high tides and two low tides. ··· happens most of the time
    e. All of the above combinations occur in some, but not most, 24 hour intervals ✗
    f. None of the above is a true statement about the occurrence of earth's tides.

13. Suppose that the acceleration due to gravity on Titan, Saturn's largest moon, is about 3.0 m/s^2. What would a 60-kg scientific instrument weigh on Titan, most nearly?
    a. 20 N
    b. 60 N
    (c.) 180 N ✓
    d. 540 N
    e. 600 N
    f. None of the above is within 10% of the correct answer.

$W = m g_T = 60 \cdot 3 = 180\,N$ on TITAN

14. An artillery shell has a mass of 100 kg. How fast would it have to move to have the same momentum as an 18-wheeler (m = 36,000 kg) rolling along at 1 km/hr?
    a. 1 m/s
    b. 10 m/s
    (c.) 100 m/s ✓
    d. 1000 m/s
    e. 10,000 m/s
    f. None of the above answers is within 10 % of the correct result.

$M_{18} v_{18} = P_{18} = (36,000)(10^3)/(60 \times 60) = m_A v_A = 100\, v_A$ (in m/s)

$\frac{36000 \times 10^3 / 10}{3600 \cdot 100} = 100\, m/s = v_A$

15. Newton's second law can be rearranged to show that the   is equal to the
    a. net work …. kinetic energy ✗
    b. change in momentum ... change in impulse ✗
    c change in net work …. kinetic energy ✗
    d. momentum ... change in impulse. ✗
    (e) net work ….change in kinetic energy ✓
    f. change in work ... change in kinetic energy ✗
    g None of the above ✗

16. For an acrobatic tumbler, a trampoline reduces the ________ that he feels when he comes back to earth.
    a. force
    b. work ✗
    c. impulse ✗
    d. change in velocity ✗
    e. change in momentum ✗
    f. None of the above. ✗

17. A tail gunner jumped from a World War II Lancaster bomber but remained unhurt because he Fell first into the branches of a tree and then into a snow bank. Physics explains this because
    a. the change in momentum was less than hitting the ground directly. ✗
    b. the impulse in less in trees and snow than ground. ✗
    c. the increased stopping time in the tree and the snow meant a smaller stopping force. ✓
    d. the decreased stopping time in the tree and the snow meant a smaller stopping force. ✗
    e. The work done is still equal to the change in kinetic energy. ✗
    f. None of the above. ✗

18. Which of the following will cause the largest change in the momentum of an object? A force of ________ acting for ________.
    a. 1 N ... 9 s = 9
    b. 2 N ... 8 s = 16
    c. 3 N ... 7 s 21
    d. 4 N ... 6 s 24
    e. 5 N ... 5 s = 25 = $F\Delta t$ ← MAX VALUE: Largest change Δp
    f. 6 N ... 4 s 24

19. Approximately what average force is required to stop a 0.25kg baseball moving at 3 m/s in a distance of 2 cm? (WORK ENERGY THEOREM)
    a. 56 N ✓
    b. 37 N
    c. 19 N
    d. 0.56 N
    e. 0.37 N
    f. 0.19 N
    ~~f.~~ g. None of the above is within 10% of the correct answer.

$F \cdot d = W = \Delta(KE) = \frac{1}{2}(0.25)(3)^2$

$d = 2\times10^{-2}\,m$

$F = \frac{1}{2}(.25)\frac{9}{2\times10^{-2}} = \frac{9}{16}\times10^{2} = 56.25$

20. A very hard rubber ball (m = 0.4 kg) is falling vertically at 1.5 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 $0.003 = 3\times10^{-3}$ s, what is the average force exerted by the floor on the ball?
    a. 20 N
    b. 40 N
    c. 200 N
    d. 400 N ✓
    e. None of the above is within 10% of the correct answer.

$F\Delta t = P_f - P_i$ (IMPULSE MOMENTUM THEOREM)

$= (0.4)(1.5) - (-0.4)(1.5) = 1.2\ kg\ m/s$

Then $F = 1.2/3\times10^{-3} = 0.4\times10^{3} = 400\ \frac{kg\cdot m}{s^2} = 400\ N$

21. If we examine a ball in free fall, we find that the momentum of the ball is not constant. This is not a violation of the law of conservation of momentum because
    a. The force of gravity acts on the ball. ✓
    b. The ball experiences an external force. ✓
    c. The ball is not an isolated system. ✓
    d. A net work is done on the ball by an outside force as it falls ✓
    (e.) All of the above are correct answers. ✓

22. When a star undergoes a supernova explosion, the total linear momentum of the star
    a. increases slowly ✗
    b. increases suddenly in the outward direction ✗
    (c.) remains constant ✓ CONS of MOMENTUM for isolated system
    d. decreases rapidly at first and then more slowly as the star expands. ✗
    e. decreases at a nearly uniform rate once the explosion has occurred.
    f. There is not enough information to say. ✗
    g. None of the above is correct. ✗

23. We can explain the recoil that occurs when a rifle is fired, we need
    a. the Work-Energy Theorem. ✗
    b. conservation of mechanical energy ✗
    c. Newton's second law. ✗
    (d.) Newton's third law. ✓
    e. Any of the above ✗
    f. None of the above completions yields a correct statement. ✗

24. Larry has a mass of 90 kg and runs across the classroom with a speed of 4 m/s and jumps onto a giant skateboard, initially at rest and with a mass equal to 10kg. If we ignore friction, what is the final speed of Larry and the skateboard, most nearly?
    a. 2 m/s
    (b.) 3.6 m/s
    c. 3.8 m/s
    d. 22.5 m/s
    e. 40 m/s
    f. None of the above is within 10% of the correct answer.

$0 + 90 \cdot 4 = (90+10) v_f \Rightarrow v_f = \frac{360}{100} = 3.6 \text{ m/s}$

Since $P_i^{TOT} = P_f^{TOT}$

25. Which of the following properties of a ball is conserved as it falls freely in a vacuum?
    a. kinetic energy ✗
    b. gravitational potential energy ✗
    c. momentum ✗
    (d.) mechanical energy ✓
    e. None of the above is conserved. ✗

26. Under what conditions is the kinetic energy (KE) conserved, in the strict sense of the word, during a collision?
   a. It is always conserved. ✗
   b. When the collision is totally elastic. ✗
   c. When there is no net outside force ✗
   d. When there is no friction ✗
   (e.) KE is never conserved during a collision because its value does not remain constant. ✓
   f. None of the above is correct. ✗

27. A ball moving at 4 m/s toward the right has a head-on collision with an identical ball moving to the left at 2 m/s. Each of the following final velocity pairs satisfies the law of conservation of linear momentum. Which one also preserves kinetic energy? One ball has a velocity of __________ while the other has a velocity of __________ to the right.
   a. 1 m/s to the right … 1 m/s ✗
   b. zero … 2 m/s ✗
   c. 1 m/s to the left…5 m/s ✗
   (d.) 2 m/s to the left … 4 m/s ✓
   e. 4 m/s to the left … 6 m/s ✗
   f. None of the above has a final kinetic energy equal to the initial value. ✗

28. A 4-kg toy car with a speed of 5 m/s collides head-on with a stationary 6-kg car. After the collision, the cars are locked together and travel with a speed of 2 m/s. How much kinetic energy is lost in the collision?
   a. 20 J ✓
   (b.) 30 J ✓
   c. 40 J
   d. 50 J
   e. 60 J
   f. Because kinetic energy is conserved, no kinetic energy is lost in the collision
   g. None of the above is within 10% of the correct value.

$P_i = P_f$ (Conservation of Momentum)

$4 \cdot 5 + 0 = (M_1 + M_2) v_f = 10 v_f \Rightarrow v_f = 2.0$ m/s

$(KE_i - KE_f) = \{\frac{1}{2} 4 (5)^2 + 0\} - \frac{1}{2} (6+4)(2)^2 = 50 - 20 = 30$ J

29. In physics, **net work** is defined as the product of the
   a. net force and the distance traveled. ✗
   (b.) net force parallel to the motion and the distance traveled. ✓
   c. net force parallel to the motion and the time it is applied. ✗
   d. applied force and the distance traveled. ✗
   e. net force and the time it is applied. ✗
   f. None of the above. ✗

30. Two objects have different masses but the same kinetic energy. If you stop them with the same retarding force, which one will stop in the shorter time?
   a. The heavier one.
   (b.) The lighter one.
   c. The one with the larger momentum.
   d. Both stop in the same time.
   e. There is not enough information to say
   f. There is enough information to say, but none of the above is correct.

WORK ENERGY THEOREM: $\Delta(KE) = F \Delta x$

$\Rightarrow$ THEY STOP IN SAME DISTANCE.

THEN FASTER ONE STOPS IN SHORTER TIME

& FASTER ONE IS LIGHTER ONE:

$\frac{M_L v_L^2}{2} = \frac{M_H v_H^2}{2}$

$v_L^2 = \frac{M_H}{M_L} v_H^2 > v_H^2$

31. Two objects have different masses but the same momentum. If you stop them with the same retarding force, which one will stop in the shorter time?
   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. There is enough information to say, but none of the above is correct. ✗

IMPULSE MOMENTUM THEOREM: $\Delta P = F\Delta t$ $\Rightarrow \Delta t = \frac{\Delta P}{F}$ IS SAME for both

32. The kinetic energy of an object moving in a circle at a constant speed
   a. is continually changing as the force changes direction. ✗
   b. is equal to the force times the time for one revolution. ✗
   c. is equal to one-half of the potential energy ✗
   (d.) is constant. ✓ $= \frac{1}{2} m v^2 =$ constant
   e. depends upon the radius of the circle. ✗
   f. None of the above. ✗

33. How much work is performed by the gravitational force F on a geosynchronous satellite during one day?
   a. The work done is F*C, where C is the circumference of the orbit ✗
   b. The work done is Fr, where r is the radius of the orbit. ✗
   c. The work done is zero, because the net force vanishes. ✗ does NOT!
   d. The work done is zero, because the satellite does not move ✗ does MOVE!
   (e.) The work done is zero, but not for the reasons given in c) and d) above. ✓
   f. None of the above. ✗

34. If we examine a ball in free fall in a vacuum, we find that the kinetic energy of the ball increases. This does not constitute a violation of the law of conservation of mechanical energy because the
   a. force of gravity does no work on the ball. ✗
   b. system is a closed system. ✗
   (c.) the gravitational potential energy decreases to compensate. ✓
   d. The outside world performs work on the ball during its fall. —true, but less definitive than (c)
   e. All of the above statements are correct. ✗
   f. None of the above completions is correct.

35. A 13-kg mass is released from rest at the top of a frictionless slide that is 3 m high. What is the kinetic energy of the mass when it reaches the bottom?
   a. 630 J
   (b) 390 J
   c. 145 J
   d. 58.5 J
   e. None of the above answers is within 10% of the correct result.

CONSERVATION OF MECHANICAL ENERGY
$(KE + PE)_i = (KE + PE)_f$ $\quad (PE)_i = mgh$
$(0 + 13(3)10) = (KE)_f + 0 = 390J$

36. A 800-kg frictionless roller coaster starts from rest at a height of 30 m. What is its kinetic energy when it goes over the top of a hill that is 15 m high?
    a. 4000 J
    b. 12,000 J
    c. 40,000 J
    d 80,000 J
    (e.) 120,000 J
    f. None of the above answers is within 10% of the correct result.

Cons of ME. $(PE)_i + (KE)_i = (PE)_f + (KE)_f$

$(800)(30)(10) + 0 = (800)(15)(10) + (KE)_f$

$(800)(10)(30-15) = (KE)_f$

$120{,}000\text{ J} = (KE)_f$

37. A rubber ball dropped from a height of 8 m bounces back only to a height of 7 m. Which of the following statements is valid for this situation?
    a. Kinetic energy is conserved. ✗
    b. Mechanical energy is conserved. ✗
    c. Gravitational potential energy is conserved. ✗
    (d.) Mechanical energy was lost to heat. ✓
    e. All of the above ✗
    f. None of the above. ✗

38. How much energy is required to light a 70-W bulb for 2 h?
    (a.) 5.0×10^5 J
    b. 2.5×10^5 J
    c. 8.4×10^3 J
    d. 4.2×10^3 J
    e. None of the above answers is within 10% of the correct result.

$1\text{ W} = 1\text{ J/s}$

$E = P \cdot t: 70\frac{\text{J}}{\text{s}} \times 2 \times 60 \times 60\text{ s} = 140 \times 3600 = 1.4 \times 3.6 \times 10^2 \times 10^3\text{ J} = 5.04 \times 10^5\text{ J}$

39. Imagine riding in a glass-walled elevator that goes up the outside of a tall building at a constant speed of 15 meters per second. Assuming that you release a ball as you pass a window washer, the window washer will see the ball
    a. fall starting from rest. ✗
    b. rise, then fall, starting with an upward speed of 15–g = 5 m/s. ✗
    c. fall starting with a downward speed of 15+g = 25m/s. ✗
    (d) rise, then fall, starting with an upward speed of 15 m/s ✓
    e. fall starting with a downward speed of 15 m/s ✗
    f. remain stationary. ✗
    g. None of the above statements is true ✗

40. While you are standing on the ground, you observe your friends pass by in a van traveling at a constant velocity. They drop a ball and you all make measurements of the ball's motion. Which of the following quantities has the same value in both reference systems?
    a. velocities ✗
    (b.) forces ✓
    c. mechanical energies ✗
    d. total momenta ✗
    e. kinetic energies ✗
    f. No physical quantity is the same in both reference systems ✗

41. Assume that you are riding in a windowless room on a perfectly smooth surface. (You can't feel any motion.) Imagine that you have a collection of objects and measuring devices in the room. Which of the following experiments could prove that the room is moving horizontally at a constant velocity?
   a. Determining an object's mass by applying a net horizontal force. ✗
   b. Weighing an object and comparing it to its known weight. ✗
   c. Determining the force necessary for an object to move in a circle. ✗
   d. Measuring the verticality of a hanging object ✗
   e. Measure the range of a projectile to see a deviation from the expected value. ✗
   (f.) None of the above. ••• IN FACT NO EXPERIMENT CAN ESTABLISH a constant velocity motion.

42. You can throw a ball vertically up in a car moving with a constant velocity and have it drop back into your hand because
   (a.) there is no net horizontal force acting on the ball. ✓ & so ball moves horizontally with its initial velocity = car's vel.
   b. the reference system attached to the car is non-inertial. ✗
   c. there is a net force in the forward direction ✗
   d. the force in the forward direction is canceled by the inertial force ✗
   e. None of the above. ✗

43. A person drops a ball in train traveling along a straight, horizontal track at a constant velocity of 70 mph. What would the person in the train say about the horizontal forces acting on the ball?
   (a.) There are no horizontal forces acting on the ball. ✓
   b. There is a fictitious (inertial) force acting forward. ✗
   c. There is a fictitious (inertial) force acting backward. ✗
   d. There is a centrifugal force. ✗
   e. None of the above. ✗

44. A rock is thrown horizontally at 20 m/s from the back of a flatbed truck that is moving with a constant velocity of 50 m/s. Relative to an observer on the ground, what is the horizontal velocity of the rock when it is thrown in the backward direction?
   (a.) 30 m/s forward
   b. 20 m/s backward
   c. 30 m/s backward
   d. 70 m/s forward
   e. 50 m/s on average
   f. None of the above.

   $v = -20 + 50 = +30$ (forward)
   since $\vec{v} = \vec{v}' + \vec{V}$.

45. An aircraft carrier is moving to the north at a constant 25 mph on a windless day. A plane requires a speed relative to the air of 170 mph to take off. How fast must the plane be traveling relative to the deck of the aircraft carrier to take off if the plane is headed north?
   a. 25 mph ✗
   b. 50 mph ✗
   c. 120 mph ✗
   (d.) 145 mph ✓
   e. 170 mph ✗
   f. None of the above is correct within 10%. ✗

   $170 = 25 + v' \Rightarrow v' = 170 - 25 = 145$ mph
   since $V = v' + V$

46. A ball is thrown horizontally at 60 m/s from a flatcar that is moving in a straight line at 80 m/s. Relative to a person on the ground, what is the horizontal speed of the ball when it is thrown directly sideways?
    a. 100 m/s
    b. 80 m/s
    c. 60 m/s
    d. 40 m/s
    e. 20 m/s
    f. None of the above.

$|\vec{v}| = \sqrt{(80)^2 + (60)^2} = 100$

47. An observer drops a ball in a train traveling along a straight, horizontal track with a constant acceleration in the forward direction. What would an observer in the train infer about the force acting on the ball?
    a. The force has no horizontal component. ✗
    b. The force has no vertical component. ✗
    c. The force has a horizontal component in the forward direction. ✗
    d. There is a centrifugal force. ✗
    e. The force has a horizontal component in the backward direction. ✓: $F_{pseudo} = -m\vec{A}$
    f. None of the above. ✗

48. An elevator is moving downward and speeding up with an acceleration equal to one-quarter that of gravity. If a person who weighs 1000 N when at rest on Earth steps on a bathroom scale in this elevator, what will the scale read, most nearly ?
    a. 250 N
    b. 750 N ✓
    c. 1000 N
    d. 1250 N
    e. None of the above is within 10 % of the correct result.

$a = -g/4$, $mg = 1000$; $F = -mg + F_{sc.} = ma$ (NII IN INERTIAL FRAME)
$F_{sc} = -mg/4 + mg = \frac{3}{4} mg = 750$
OR: IN ELEVATOR FRAME: $F_{sc} + F_G + F_{pseudo} = m\vec{a}' = m \cdot 0$; $F_{pseudo} = mg/4$
$F_{scale} = -F_g - F_{pseudo} = +mg - \frac{mg}{4} = \frac{3}{4} mg = 750 N$

49. A room is being accelerated through space at 5 m/s^2 relative to the "fixed stars." It is far away from any massive objects. If a man weighs 700 N when he is at rest on earth, how much will he weigh in the room, most nearly ?
    a. zero
    b. 350 N ✓
    c. 700 N
    d. 1050 N
    e. 1400 N
    f. None of the above answers is within 10% of the correct result.

$-m\vec{A} = F_{pseudo} = -m \cdot 5 = \frac{700}{10} \cdot 5 = 350 N$
(Since $mg = 700 N \Rightarrow m = \frac{700}{10} = 70$ kg.)

50. 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 pseudo-force in the rotating frame. What is the magnitude of the person's weight in the rotating reference frame, most nearly?
    a. 600 N
    b. 800 N
    c. 1000 N
    d. 1200 N
    e. 1400 N
    f. None of the above answers is within 10% of the correct result.

$W = \sqrt{(600)^2 + (800)^2} = \sqrt{100 \cdot (100)^2} = 1000 N$

51. Which of the following could be cited as evidence that the earth rotates?
    a. The plane of a pendulum rotates in an earthbound lab. ✓
    b. The sun rises and sets each day. ✓
    c. Hurricane winds rotate counterclockwise in the Northern Hemisphere; clockwise in the Southern. ✓
    d. A high precision measurement of the weight of a standard mass yields a slightly smaller value at sea level on the equator than at the north pole. ✓
    (e.) All of the above. ✓
    f. None of the above answers is correct. ✗

52. The center of mass of an extended object
    a. can not always be defined. ✗
    b. will not be the same on the moon's surface as on the earth's. ✗
    c. may follow a spiral-helical trajectory if the object rotates while it falls. ✗
    (d.) behaves like a point mass subject to all of the forces exerted on the body ✓
    e. always lies at the focal point of the ellipse if the object has an ellipsoidal shape ✗
    f. None of the above answers is correct. ✗

The following problems may require more than average numerical computation. Place the letter of the most nearly correct answer into the corresponding line on your NCS answer sheet.

53. An 900-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 0.08 = 8×10^{-2} m/s^2. What is the gravitational force on the satellite?
    a. 5.76 N
    b. 7.2 N
    c. 57.6 N
    (d) 72 N ✓
    e. 576 N
    f. 720 N
    g. None of the above answers is correct within 10 %.

(NII) $F_G = Ma = (900)(8 \times 10^{-2}) = 72\ N$

54. Assume that the mass of some distant planet is the same as the earth's mass ($6x10^{24}$ kg), that the mass of its moon is $7x10^{22}$ kg, and that they are separated by $6.4x10^9$ m. Given that $G = 6.7x10^{-11}$ N-m²/kg², and that the radius of the earth is $6.4x10^6$ m, the acceleration of the moon towards its planet is, most nearly:

a. 10^{-4} m/s².
(b.) 10^{-5} m/s². ✓
c. 10^{-6} m/s².
d. 10^{-7} m/s².
e. 10^{-8} m/s².
f. None of the above answers is within 50 % of the correct answer.

$$a_M = \frac{F}{m_M} = \frac{G M_P m_M}{(R_{PM})^2} \cdot \frac{1}{m_M} = \frac{G M_P}{(R_E)^2} \cdot \frac{(R_E)^2}{(R_{PM})^2}$$

USING EQUALITY of $M_P = M_E$ & $\{10 = g = G M_E / R_E^2\}$

$$= 10 \cdot \left(\frac{6.4 \times 10^6}{6.4 \times 10^9}\right)^2 \frac{m}{s^2} = 10 \cdot 10^{-6} = 10^{-5} \frac{m}{s^2}$$

OR BY DIRECT CALCULATION

$$a_m = \frac{(6.7 \times 10^{-11})(6 \times 10^{24})}{(6.4 \times 10^9)^2} = \frac{(6.7)(6)}{(6.4)^2} \times 10^{-11+24-18} = 0.98 \times 10^{-5} \approx 1 \times 10^{-5}\ m/sec^2$$

55. A 0.5-kg air track sled (#1) traveling to the right with a speed of 6 m/s collides inelastically with a similar 1.5-kg sled (#2) traveling to the left with a speed of 2 m/s. The two stick together and move away as a single unit after the collision. Calculate their final velocity.

a. 1 m/s to the right
b. 1 m/s to the left
c. 2 m/s to the right
d. 2 m/s to the left
e. 4 m/s to the right
f. 4 m/s to the left
(g.) None of the above answers is within 10% of the correct result. ✓

$P_i^{TOT} = P_f^{TOT}$: $+(0.5)(6) - (1.5)(2) = 3 - 3 = 0 = P_i$

[CONS of MOMENTUM]

i.e. $P_f = (0.5 + 1.5) \cdot v_f = 0$

Therefore $\boxed{v_f = 0.}$

56. A 67-kg stunt man falls feet first 45 m from a platform into an airbag. If the maximum force his feet and legs can safely withstand is 4000 N, what is the least value which the airbag must provide for his slowing down time?
   a. 5 s
   b. 0.5 s
   c. $0.05 = 5 \times 10^{-2}$ s
   d. $0.005 = 5 \times 10^{-3}$ s
   e. 5×10^{-4} s
   f. 5×10^{-5} s
   g. None of the above answers is within 50% of the correct result.

IMPULSE = $\Delta \vec{P} = F \Delta t = M v_f$ where v is impact speed.

If $F = F_{MAX}$ $\Delta t = (Mv)/F_{MAX}$

CONS of MECH. ENGY yields v: $(PE)_i + (KE)_i = (PE)_f + (KE)_f$

$(67)(45)(10) + 0 = \frac{1}{2}(67) v^2$

$30 \frac{m}{s} = \sqrt{900} = v$

THEN $\Delta t = \frac{(67)(30)}{4000} \frac{N s}{N} = 0.5025$

57. A 10 kg block of wood loses 260 J of mechanical energy to friction as it slides down a ramp starting at rest. If it has 640 J of kinetic energy at the bottom of the ramp, we can conclude that it started at a height of
   a. 3 m
   b. 9 m
   c. 27 m
   d. 90 m
   e. 260 m
   f. 640 m
   g. None of the above answers is within 10% of the correct result.

CONSERVATION of ENERGY.

INITIAL ENERGY − ENERGY LOST = FINAL ENERGY

$(PE)_i + (KE)_i - (260 J) = (PE)_f + (KE)_f$

$(10)(10)h_i + 0 - 260 J = 0 + 640$

$\Rightarrow h_i = \frac{900}{100} = 9 m$

58. A 15-N block impelled straight upward by a steady net force of 8 N has at some instant an initial kinetic energy of 26 J due to its upward motion. If the block is lifted an additional 8 m from that point, what is the block's final kinetic energy, most nearly?

a. 90 J
b. 70 J
c. 50 J
d. 30 J
e. 10 J
f None of the above answers is within 10% of the correct result.

WORK-ENERGY THEOREM $W^{NET} = (KE)_f - (KE)_i$

$\Rightarrow (KE)_f = (KE)_i + W^{NET} = 26J + (8\cdot 8)J = 90J$

59. An observer drops a ball in a train traveling along a straight, horizontal track under a constant acceleration of 7.5 m/s^2 in the forward direction. The observer in the train measures that the acceleration of the ball has (most nearly) the magnitude,

a. 7.5 m/s/s
b. 10 m/s/s
c. 12.5 m/s/s
d. 15 m/s/s
e. 25 m/s/s
f. None of the above answers is within 10% of the correct result.

$|\vec{A}| =$

$10 = g$

$\vec{F}_G + \vec{F}_{pseudo} = m\, a_B$, & $\vec{F}_{pseudo} = -m\vec{A}$

$(0, -10m) + (-7.5m, 0) = m(a_x, a_y)$

$a_x = -10,\ a_y = -7.5$

$|\vec{a}| = \sqrt{a_x^2 + a_y^2}$

$= \sqrt{100 + (7.5)^2}$

$= 12.5\ m/s^2$

60. A cylindrical space station, far from any large masses, can be made to rotate about its long axis so that people on the inside surface of the station feel "artificial gravity" due to a centrifugal inertial (or pseudo-) force directed outward through the inner surface of the cylinder. If the cylinder has a radius of 100 km, what must its angular velocity be, most nearly, in order to provide an artificial gravity acceleration just equal to g = 10 m/s^2?

a. 10^{-4} radians/sec
b. 10^{-3} radians/sec
c. 10^{-2} radians/sec ✓
d. 10^{-1} radians/sec
e. None of the above answers is within 50% of the correct result.

IF $\frac{F_{pseudo}}{m} = g = \frac{mv^2}{mR} = \frac{(R\omega)^2}{R} = R\omega^2$

THEN $\omega = \sqrt{g/R}$

$= \sqrt{\frac{10}{100 \times 10^3}} = \sqrt{10^{-4}}$

$= 10^{-2}$ rad/sec

........End of Exam