PHYSICSBOWL 2014

April 2 – April 16, 2014

40 QUESTIONS – 45 MINUTES

The sponsors of the 2014 PhysicsBowl, including the **American Association of Physics Teachers**, are providing some of the prizes to recognize outstanding high school physics students and their teachers through their performance on this year's contest.

- Schools compete in one of fourteen regions, each with two divisions.
  - *Division 01* is for students *taking physics for the first time* (even if that first course is AP Physics).
  - *Division 02* is for students taking a second (or more) course in physics or anyone wishing a challenge.
- A school's team score in each division is the sum of the ***five*** highest student scores in that division.
- A school may compete in either or both divisions.

INSTRUCTIONS

Answer sheet: Write and bubble-in the following **REQUIRED** information on your answer sheet:

- Your *Name*
- Your *School's CEEB code* (given to you by your teacher)
- Your *Teacher's AAPT Teacher code* (given to you by your teacher – only ***one*** code per school!)
- Your *Region* (given to you by your teacher)
- Your *Division* (01 for first-year physics students, 02 for students in a second physics course)

If this information is not properly bubbled, ***you will be disqualified*** as your official score will be a zero.

Your answer sheet will be machine graded. Be sure to use a *#2 pencil*, fill the bubbles completely, and make no stray marks on the answer sheet.

Questions: The test is composed of 50 questions; however, students answer only 40 questions. Answers should be marked on the answer sheet next to the number corresponding to the question number on the test.

Division 01 students will answer only questions 1 – 40. Numbers 41 – 50 on the answer sheet should remain blank for all Division 01 students.

Division 02 students will answer only questions 11 – 50. Numbers 1 – 10 on the answer sheet should remain blank for all Division 02 students.

Calculator: A hand-held calculator may be used. Any memory must be cleared of data and programs. Calculators may not be shared.

Formulas and constants: Only the formulas and constants provided with the contest may be used.

Time limit: *45 minutes.*

Score: Your score is equal to the number of correct answers (no deduction for incorrect answers). If there are tie scores, the entries will be compared, from the end of the test forward, until the tie is resolved. Thus, the answers to the last few questions may be important in determining the winner, and you should consider them carefully.

Good Luck!

ATTENTION: **All Division 01 students, START HERE.**
All Division 02 students – skip the first 10 questions and begin on #11.

***** Treat $g = 10.0\ {}^{m}/_{s^2}$ for ALL questions #1 – #50.**

1. An FM radio station sends a signal with a frequency of $99.99\ \times 10^6\ Hz$. Which one of the following choices best represents this frequency expressed using metric prefixes?

(A) $99.99\ kHz$ **(B)** $99.99\ MHz$ **(C)** $99.99\ GHz$ **(D)** $99.99\ THz$ **(E)** $99.99\ nHz$

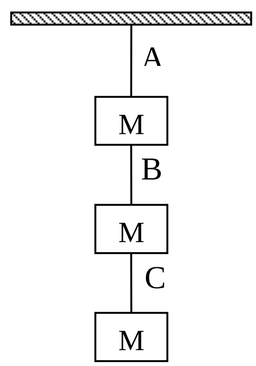
2. In the laboratory, a student makes the following six measurements for the length of an object: $5.05\ cm$, $5.06\ cm$, $5.07cm$, $5.06\ cm$, $5.07\ cm$, and $5.09\ cm$. Using the rules of significant digits, which one of the following choices correctly represents how she should express the average length of the object?

(A) $5\ cm$ **(B)** $5.06\ cm$ **(C)** $5.06\bar{6}\ cm$ **(D)** $5.07\ cm$ **(E)** $5.1\ cm$

3. An object is dropped into free fall. Through how many meters does the object fall during the first 3.00 seconds of flight?

(A) $10.0\ m$ **(B)** $15.0\ m$ **(C)** $30.0\ m$ **(D)** $45.0\ m$ **(E)** $90.0\ m$

4. Three equal masses are suspended from a classroom ceiling by a series of strings as shown in the figure. Which string has the greatest tension?



(A) Only String A
(B) Only String B
(C) Only String C
(D) Strings A, B, and C have the same non-zero tension.
(E) Strings A, B, and C all have no tension.

5. A simple pendulum consists of a massive bob connected to the end of a very light string. Which one of the following changes should be made in order to increase the period of the pendulum? Ignore air resistance.

(A) Increase the mass of the bob
(B) Decrease the mass of the bob
(C) Increase the length of the string
(D) Decrease the length of the string
(E) Decrease the maximum angle of the pendulum's oscillation

6. MRI is a commonly used acronym for a medical diagnostic technique. MRI stands for which one of the following choices?

(A) Medical Radio Imaging
(B) Minimally Radioactive Intervention
(C) Multiaxis Radar Injection
(D) Magnetic Radioisotope Injection
(E) Magnetic Resonance Imaging

7. Starting from rest, a cart uniformly accelerates to a speed of $7.60\,\frac{m}{s}$ in a time of $3.00\ s$. Through what distance does the cart move in this time?

(A) $5.7\ m$ **(B)** $8.1\ m$ **(C)** $11.4\ m$ **(D)** $16.1\ m$ **(E)** $22.8\ m$

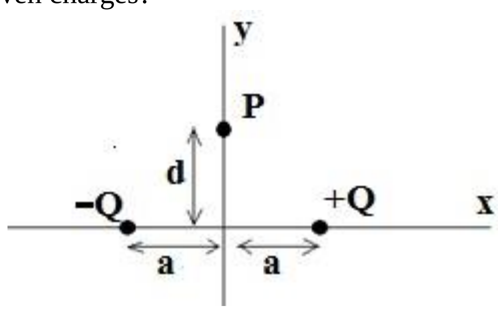
8. A $2.50\ kg$ mass connected to the end of an ideal spring oscillates in simple harmonic motion. The mass's position is described as a function of time by $x(t) = 0.20\ \cos(8.00\ t + 0.50)$ where all quantities are in base SI units. Which one of the following choices gives the numerical value of the oscillation's amplitude in base SI units?

(A) 8.00 **(B)** 4.00 **(C)** 1.60 **(D)** 0.50 **(E)** 0.20

9. Which one of the following quantities is not a scalar quantity?

(A) Force **(B)** Energy **(C)** Mass **(D)** Speed **(E)** Pressure

10. Two charges, $-Q$ and $+Q$, are fixed in place on the x-axis, each a distance a from the origin as shown. At the point labeled P, a distance d along the y-axis from the origin, what is the direction of the electric field from the given charges?



(A) Up the plane of the page
(B) Down the plane of the page
(C) To the right
(D) To the left
(E) There is no electric field.

ATTENTION: **All Division 01 students, continue to question #40.**
All Division 02 students, START HERE. Numbers 1 – 10 on your answer sheet should be blank. Your first answer should be for #11.

***** Treat $g = 10.0\ {}^{m}/_{s^2}$ for ALL questions #1 – #50.**

11. A crate gains $36.0\ J$ of kinetic energy while its speed is increased from $2.00\,\frac{m}{s}$ to $4.00\,\frac{m}{s}$. Which one of the following choices best represents the mass of the crate?

(A) $36.0\ kg$ **(B)** $18.0\ kg$ **(C)** $6.0\ kg$ **(D)** $3.0\ kg$ **(E)** $1.5\ kg$

12. A box of mass $5.0\ kg$ is being pushed to the right across a horizontal surface while a constant frictional force of $8.0\ N$ acts on the box. At some instant of time, the box has a speed of $4.0\,\frac{m}{s}$ and an acceleration of $3.0\,\frac{m}{s^2}$. What is the magnitude of the net force acting on the box at this instant?

(A) $7.0\ N$ **(B)** $12.0\ N$ **(C)** $15.0\ N$ **(D)** $20.0\ N$ **(E)** $23.0\ N$

13. Which one of the following scientists is most associated with the following statement: "For small displacements of an object from equilibrium, there is a restoring force that is proportional to the displacement."?

(A) Einstein **(B)** Hooke **(C)** Huygens **(D)** Kepler **(E)** Lenz

14. A box rests on the floor of an elevator. The elevator is accelerating upward. Which one of the following choices best represents the Newton's Third Law pair force to the gravitational force acting on the box by the Earth?

(A) There is no Newton's Third Law pair force in this scenario.
(B) The entire normal force of contact from the floor on the box.
(C) Only a portion of the normal force of contact from the floor on the box.
(D) The force of the cables pulling upward on the elevator.
(E) The gravitational force acting on the Earth by the box.

15. Two objects, A and B, move in space and then collide.
Before collision: Object A, of mass $5.0\ kg$, moves to the right with a speed of $25.0\,\frac{m}{s}$.
Object B, of mass $10.0\ kg$, moves to the left with a speed of $20.0\,\frac{m}{s}$.
After collision: Object A moves to the left with a speed of $25.0\,\frac{m}{s}$.
What is the velocity of object B after the collision?

(A) $30.0\,\frac{m}{s}$ to the right
(B) $20.0\,\frac{m}{s}$ to the right
(C) $20.0\,\frac{m}{s}$ to the left
(D) $5.0\,\frac{m}{s}$ to the right
(E) $5.0\,\frac{m}{s}$ to the left

Questions 16 & 17 refer to the following information:

A toy car initially moves to the right at $60.0\frac{cm}{s}$. Five seconds later, the car is moving at $40.0\frac{cm}{s}$ to the left. The total displacement of the car during this time is $10.0\ cm$ to the left of where it started.

16. Which one of the following choices best represents the magnitude of the average velocity of the car during the five second motion?

(A) $50.0\frac{cm}{s}$ **(B)** $10.0\frac{cm}{s}$ **(C)** $4.0\frac{cm}{s}$ **(D)** $2.0\frac{cm}{s}$ **(E)** $0.40\frac{cm}{s}$

17. Which one of the following choices best represents the magnitude of the average acceleration of the car during the five second motion?

(A) $20.0\frac{cm}{s^2}$ **(B)** $4.0\frac{cm}{s^2}$ **(C)** $2.00\frac{cm}{s^2}$ **(D)** $0.80\frac{cm}{s^2}$ **(E)** $0.40\frac{cm}{s^2}$

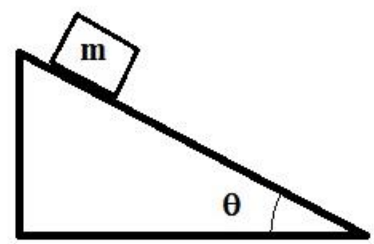
18. A rectangular block of wood has a mass of $17.8\ g$ and dimensions of length: $3.00\ cm$, width: $4.00\ cm$, and height: $2.00\ cm$. Which one of the following choices correctly gives the average density of the block?

(A) $7.42\times 10^5\frac{kg}{m^3}$ **(B)** $7.42\times 10^2\frac{kg}{m^3}$ **(C)** $7.42\ \frac{kg}{m^3}$ **(D)** $7.42\times 10^{-1}\ \frac{kg}{m^3}$ **(E)** $7.42\times 10^{-4}\ \frac{kg}{m^3}$

19. In 2013, the Nobel Prize in physics was awarded "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".
The winners were François Englert and

(A) Stephen Hawking **(B)** Edward Witten **(C)** Edwin Hubble **(D)** Brian Greene **(E)** Peter Higgs

20. A uniform block of mass m is placed on an inclined plane of angle θ. When released, the block does not move. It is determined that the normal force acting from the incline on the block has a magnitude of $62\ N$ while the force of static friction acting on the block has a magnitude of $38\ N$. The coefficient of static friction between the block and inclined plane is $\mu_s = 0.92$. Which one of the following choices best represents the mass, m, of the block?

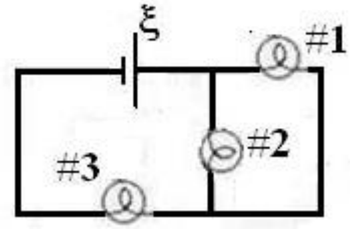


(A) $2.4\ kg$ **(B)** $6.2\ kg$ **(C)** $7.3\ kg$ **(D)** $8.4\ kg$ **(E)** $10.0\ kg$

21. A tuning fork placed over a $57\ cm$ column of air closed only at its bottom end produces a standing wave in the 3rd harmonic. The speed of sound in air is $342\frac{m}{s}$. What is the frequency of the tuning fork?

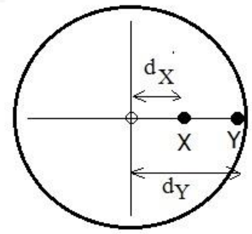
(A) $150\ Hz$ **(B)** $300\ Hz$ **(C)** $450\ Hz$ **(D)** $600\ Hz$ **(E)** $900\ Hz$

22. For the circuit shown, all three light bulbs have the same resistance. The battery and wires have no resistance. What is the proper ranking of the bulbs' brightness?



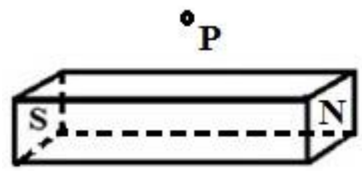
(A) Bulb 1 = Bulb 2 = Bulb 3
(B) Bulb 3 < Bulb 2 = Bulb 1
(C) Bulb 2 < Bulb 1 < Bulb 3
(D) Bulb 1 = Bulb 2 < Bulb 3
(E) Bulb 1 = Bulb 3 < Bulb 2

23. Two small identical coins (labeled X and Y) are at rest on a horizontal disk rotating at a constant rate about an axis perpendicular to the plane of the disk and through its center. The distance of the coins from the center of disk is related by $d_X = \frac{1}{2}d_Y$. Which one of the following choices correctly identifies the relationship between f_X and f_Y, the frictional force on coin X and on coin Y, respectively?



(A) $f_X = \frac{1}{4}f_Y$ **(B)** $f_X = \frac{1}{2}f_Y$ **(C)** $f_X = f_Y$ **(D)** $f_X = 2f_Y$ **(E)** $f_X = 4f_Y$

24. For the bar magnet shown in the figure, which choice best describes the direction of the magnetic field at the point P located directly above the center of the magnet?



(A) Up the plane of the page
(B) To the right
(C) Down the plane of the page
(D) To the left
(E) Out of the plane of the page

25. It is observed that a light ray changes direction when it enters a new material. Which one of the following choices is the term best associated with this phenomenon?

(A) Doppler Effect **(B)** Interference **(C)** Polarization **(D)** Diffraction **(E)** Refraction

26. A solid cube of iron and a solid cube of aluminum have equal mass. The cubes are placed into the same large pool of water so that each is completely submerged and resting on the pool's bottom. Which object experiences the greater buoyant force from the water?

(A) The iron cube
(B) The aluminum cube
(C) The buoyant forces are equal.
(D) The mass of the cubes is needed to answer the question.
(E) The answer depends on whether the pool is filled with fresh water or salt water.

27. Two spherical, non-rotating planets, X and Y, have the same uniform density ρ. Planet X has twice the radius of Planet Y. Let g_X and g_Y represent the accelerations due to gravity at the surfaces of Planet X and Planet Y, respectively. What is the ratio of $g_X : g_Y$?

(A) $2:1$ **(B)** $1:2$ **(C)** $1:1$ **(D)** $4:1$ **(E)** $1:4$

28. A waterproof speaker placed at the bottom of a swimming pool emits a sound wave that travels toward the surface of the water. In the water, the sound wave has a frequency f_{water}, wavelength λ_{water}, and wave speed v_{water}. When the sound wave enters the air it has a frequency f_{air}, wavelength λ_{air}, and wave speed v_{air}. Which one of the following relationships correctly compares the frequencies, wavelengths, and wave speeds of the waves in the air and water?

(A) $f_{water} = f_{air}$; $\lambda_{water} = \lambda_{air}$; $v_{water} = v_{air}$
(B) $f_{water} = f_{air}$; $\lambda_{water} > \lambda_{air}$; $v_{water} > v_{air}$
(C) $f_{water} < f_{air}$; $\lambda_{water} > \lambda_{air}$; $v_{water} = v_{air}$
(D) $f_{water} < f_{air}$; $\lambda_{water} = \lambda_{air}$; $v_{water} < v_{air}$
(E) $f_{water} = f_{air}$; $\lambda_{water} < \lambda_{air}$; $v_{water} > v_{air}$

29. An electron with charge $-e$ and mass m travels at a speed v in a plane perpendicular to a magnetic field of magnitude B. The electron follows a circular path of radius R. In a time t, the electron travels halfway around the circle. What is the amount of work done by the magnetic force on the electron in this time?

(A) zero **(B)** $-\pi evBR$ **(C)** $\pi evBR$ **(D)** $-2evBR$ **(E)** $\frac{-\pi mv}{eB}$

30. Considering only the Moon-Earth system (ignore any influence of the Sun), which one of the following best expresses the magnitude of the Moon's acceleration about the Earth?

(A) $3 \times 10^{-1} \frac{m}{s^2}$ **(B)** $3 \times 10^{-2} \frac{m}{s^2}$ **(C)** $3 \times 10^{-3} \frac{m}{s^2}$ **(D)** $3 \times 10^{-4} \frac{m}{s^2}$ **(E)** $3 \times 10^{-5} \frac{m}{s^2}$

31. A toy crane exerts an upward force and delivers a useful power output of $0.10\ W$ to raise a block vertically at a constant speed. At what constant speed will this crane raise a $0.20\ kg$ block?

(A) $0.01\ {}^{m}/_{s}$ **(B)** $0.02\ {}^{m}/_{s}$ **(C)** $0.05\ {}^{m}/_{s}$ **(D)** $0.20\ {}^{m}/_{s}$ **(E)** $0.50\ {}^{m}/_{s}$

32. Planck's constant is multiplied by the speed of light. The resulting value then is divided by three meters. This final value has the units of which one of the following quantities?

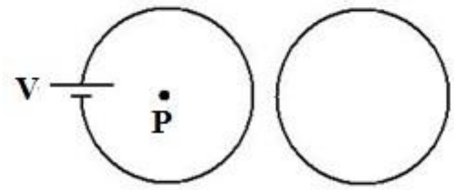
(A) Force **(B)** Linear Momentum **(C)** Speed **(D)** Frequency **(E)** Energy

33. An object moves with constant acceleration starting with velocity $v_0 = 5.00 \frac{m}{s}$ and ending with a velocity of $v = -1.00 \frac{m}{s}$ in a time of $3.00\ s$. For this motion, what is the average speed associated with the object?

(A) $2.00\ {}^{m}/_{s}$ **(B)** $2.17\ {}^{m}/_{s}$ **(C)** $2.50\ {}^{m}/_{s}$ **(D)** $2.83\ {}^{m}/_{s}$ **(E)** $3.00\ {}^{m}/_{s}$

34. Two circular loops of resistive wire are placed next to each other as in the figure. The circular loop on the left is connected to a constant voltage source V. The resistance of this loop is increasing linearly with time. As the resistance is changing, what is the direction of the magnetic field at point P (the center of the left-hand loop) and what is the orientation of the conventional current in the right-hand loop (as viewed in the figure from above)?

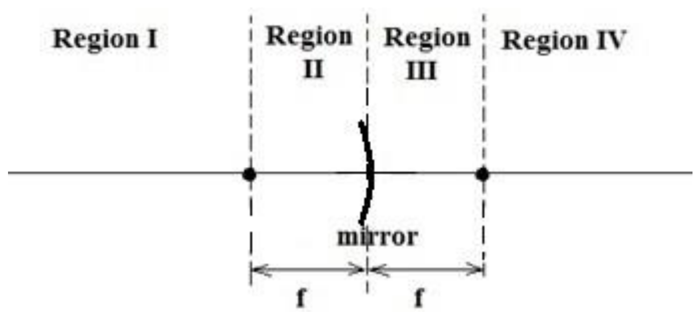
	Magnetic Field Direction	Current Orientation
(A)	Into the plane of the page	Counterclockwise
(B)	Into the plane of the page	Clockwise
(C)	Out of the plane of the page	Counterclockwise
(D)	Out of the plane of the page	Clockwise
(E)	There is no field	There is no current



35. There are several statements presented below that attempt to describe physical phenomena. Which one of the following statements is correct?

(A) The coefficient of friction is a value always less than or equal to one, but greater than or equal to zero.
(B) For horizontal surfaces, the normal force acting on an object always cancels the gravitational force.
(C) An ideal gas's temperature must change if both work is done and energy is exchanged as heat with it.
(D) Increasing the spacing between slits in the Young's double slit experiment results in an increase in the spacing between the dark regions on a distant viewing screen.
(E) In electrostatic equilibrium, an electric field is perpendicular to the surface of a charged conductor.

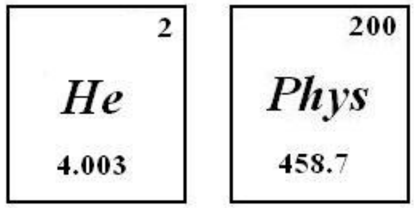
36. A concave mirror with focal length f is shown in the figure. A real object now is placed to the left of the mirror. In theory, which one of the following choices best describes everywhere that it is impossible for an image to form from the mirror?



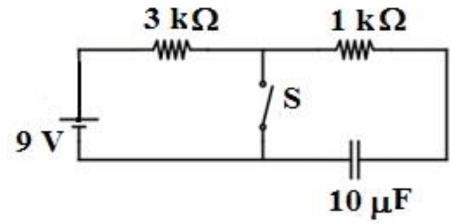
(A) Region II only.
(B) Regions II and III only.
(C) Regions III and IV only
(D) Regions II and IV only
(E) Regions I, II, and IV only

37. A new element is discovered and named PhysicsBowlium (atomic symbol *Phys*). Its entry onto the standard periodic table of elements appears as in the figure (with Helium shown as well). Given a sample of *Phys* which acts as a perfect monatomic ideal gas, what is the root-mean-square speed of the atoms of the gas if the sample is at $20^\circ C$?

(A) $1.04\ {}^{m}/_{s}$
(B) $4.00\ {}^{m}/_{s}$
(C) $33.0\ {}^{m}/_{s}$
(D) $126\ {}^{m}/_{s}$
(E) $191\ {}^{m}/_{s}$

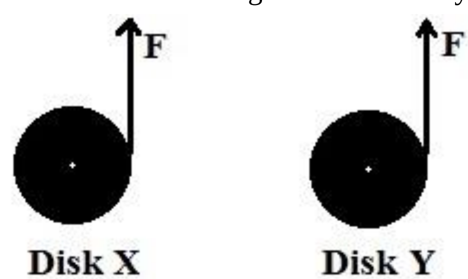


38. In the circuit shown, the switch S has been left open for a very long time. All circuits elements are considered to be ideal. Which one of the following statements best describes the behavior of the current through the switch S once it is closed?



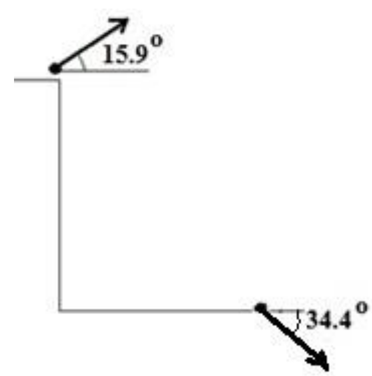
(A) The current initially is 12 mA and decreases to a steady 3 mA.
(B) The current initially is 3 mA and increases to a steady 12 mA.
(C) The current initially is 9 mA and decreases to a steady 3 mA.
(D) The current initially is 6 mA and decreases to a steady 3 mA.
(E) The current is a steady 3 mA.

39. Two uniform disks, X and Y, have masses $m_X < m_Y$, equal radii, and equal initial non-zero kinetic energies. Each disk rotates counterclockwise in the plane of the page about a fixed frictionless axis through its center. As shown in the figure, a force F is applied tangent to each disk at its right edge for the same amount of time. After the forces are applied, let L represent the magnitude of the angular momentum about the center of a disk and K represent the kinetic energy of a disk. Which one of the following choices correctly compares these quantities for disk X and disk Y?



(A) $L_X > L_Y$; $K_X < K_Y$
(B) $L_X > L_Y$; $K_X > K_Y$
(C) $L_X = L_Y$; $K_X = K_Y$
(D) $L_X < L_Y$; $K_X < K_Y$
(E) $L_X < L_Y$; $K_X > K_Y$

40. A small 1.35 kg mass is launched from the top of a cliff at an angle of 15.9° above the horizontal. When the mass reaches the ground 4.33 $seconds$ later, its velocity is directed at 34.4° below the horizontal. What is the speed of the mass when it reaches the ground? Ignore air resistance



(A) 60.7 $^m/_s$
(B) 54.1 $^m/_s$
(C) 46.4 $^m/_s$
(D) 43.3 $^m/_s$
(E) 38.8 $^m/_s$

**IMPORTANT: All Division 01 students <u>STOP HERE</u>. Your last answer should be for #40.
Numbers 41-50 should remain blank for Division 01 students.**

All Division 02 students continue to Questions 41 – 50.

ATTENTION: All Division 01 students, STOP HERE.
All Division 02 students, continue to question #50.

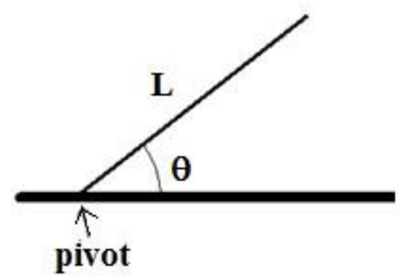
41. "No two electrons in an atom can have an identical set of the four quantum numbers." is a statement most closely associated with which one of the following scientists?

(A) Albert Einstein **(B)** Enrico Fermi **(C)** Sheldon Cooper **(D)** Wolfgang Pauli **(E)** Isaac Newton

42. Plane-polarized light with intensity I is incident on a single polarizing sheet. If the intensity of the light become $\frac{1}{4}I$ after passing through the polarizer, what is the angle between the transmission axis of the polarizer and the polarization plane of the incident light?

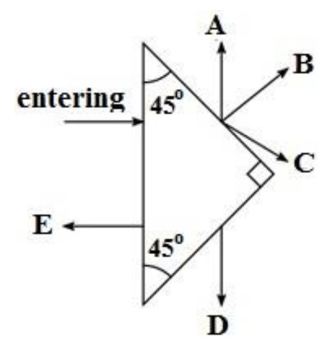
(A) 75° **(B)** 67.5° **(C)** 60° **(D)** 30° **(E)** 22.5°

43. A long rod of length L is pivoted about its left end. It is released from an angle θ above the horizontal. What is the magnitude of the angular acceleration of the rod about the pivot when the rod is released?



(A) $\left({}^{6g}/_{L}\right)\cos\theta$ **(D)** $\left({}^{3g}/_{2L}\right)\cos\theta$
(B) $\left({}^{6g}/_{L}\right)\sin\theta$ **(E)** $\left({}^{3g}/_{L}\right)\sin\theta$
(C) $\left({}^{3g}/_{2L}\right)\sin\theta$

44. A ray of monochromatic light enters the right-triangular glass as shown. The glass has an index of refraction of 2.00 and it is surrounded by air. Which one of the lettered rays shows the path of the light after it exits the glass?



(A) A
(B) B
(C) C
(D) D
(E) E

45. A long thin rod of mass M and length L is pivoted at one end so that it swings as a pendulum. The rod is set into simple harmonic oscillation and has a period of motion T. A second thin rod with mass $2M$ and length $2L$ also is pivoted at one end to swing as a pendulum. When this second rod is set into simple harmonic oscillation, what is its period?

(A) $2T$ **(B)** $\sqrt{2}\,T$ **(C)** T **(D)** $\frac{1}{\sqrt{2}}\,T$ **(E)** $\frac{1}{2}\,T$

46. A monatomic, ideal gas undergoes an isobaric process. During the process, the gas performs 80 joules of work on the surroundings. Which one of the following statements best describes the heat exchange during this process?

(A) 200 joules of energy was added to the gas.
(B) 200 joules of energy was removed from the gas.
(C) 80 joules of energy was added to the gas.
(D) 80 joules of energy was removed from the gas.
(E) It cannot be determined without knowing the change in temperature for the gas.

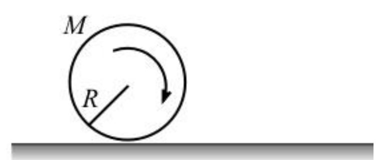
47. An air-filled parallel-plate capacitor of capacitance C is fully charged after being connected to a battery of voltage V. The battery then is disconnected and an insulating dielectric slab of constant κ is inserted between the capacitor's plates, fully filling the region. What is the voltage between the plates once equilibrium is established with the dielectric in place?

(A) $\kappa^2 V$ **(B)** κV **(C)** V **(D)** V/κ **(E)** V/κ^2

48. A laser beam with wavelength $632.8\ nm$ shines onto a newly fabricated single slit. As a result, the width of the principal bright region on a viewing screen $1.25\ m$ away is $1.00\ m$. Which one of the following best represents the size of the single slit opening?

(A) $0.79\ \mu m$ **(B)** $0.85\ \mu m$ **(C)** $1.01\ \mu m$ **(D)** $1.58\ \mu m$ **(E)** $1.70\ \mu m$

49. A solid, uniform disk of mass M and radius R rotates clockwise about its center with an angular speed ω_0. The disk then is placed onto a horizontal surface and begins moving only to the right, slipping as it rolls. The coefficient of friction between the floor and the disk is μ and the frictional force is considered constant throughout the motion. What is the angular speed of the disk when the disk starts rolling without slipping?



(A) $\frac{\mu}{2}\omega_0$ **(B)** $\frac{1}{2}\ \omega_0$ **(C)** $\frac{1}{3}\omega_0$ **(D)** $\frac{2\mu}{3}\omega_0$ **(E)** $\frac{3}{5}\ \omega_0$

50. Two clocks, A and B, are synchronized on Earth. Clock A is placed onto a space ship that leaves Earth in a straight line with a speed of $2.40 \times 10^8 \frac{m}{s}$. On Earth, a scientist with clock B has her telescope fixed directly on clock A. If each clock started at $t = 0s$, what time does the scientist observe on clock A when clock B reads $t = 90s$? Assume the time of acceleration for the ship leaving the Earth was negligible.

(A) $24\ s$ **(B)** $30\ s$ **(C)** $50\ s$ **(D)** $54\ s$ **(E)** $72\ s$

IMPORTANT: All Division 02 students <u>STOP HERE</u>. Your last answer should be for #50.