MEHS ROUND 16

TOSS-UP

1) Physics – *Short Answer* A sound wave travels in a medium that is four times as dense as the medium that another sound wave is traveling in. However, the other sound wave has double the amplitude of the first sound wave, and has the same angular frequency and velocity. By what factor is the intensity of the first sound wave larger than the intensity of the second sound wave?

ANSWER: 1

BONUS

1) Physics – *Short Answer* In a magical parallel universe ice cream gets colder as its surroundings get warmer without any work done on the ice cream by an external force. For this to happen, what quantity must be negative?

ANSWER: ENTROPY

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TOSS-UP

2) Chemistry – *Multiple Choice* A compound with the formula C6H12 does not decolorize bromine in CHCl3 solution. Which compound could this be?

W) 1-hexene
X) Trans 3-hexene
Y) Cyclohexane
Z) 3-methyl 1-pentene

ANSWER: Y) CYCLOHEXANE

BONUS

2) Chemistry – *Short Answer* The hydride of which two elements can be used in the reduction of aldehydes or ketones to alcohols?

ANSWER: LITHIUM, ALUMINUM (MUST HAVE BOTH) (ACCEPT: AL, LI)
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TOSS-UP

3) Energy – *Multiple Choice* Scientists at Oak Ridge National Lab have been using neutron-neutron scattering to reveal the behavior of cholesterol on membranes. In the lipid bilayer, cholesterol is found in abundance in lipid rafts. Which of the following statements regarding lipid rafts is NOT true?

W) Lipid rafts are more loosely packed than the surrounding bilayer
X) Lipid rafts are enriched in sphingolipids
Y) Lipid rafts in the cell membrane influence membrane fluidity and protein trafficking
Z) Lipid rafts are involved in signal transduction processes

ANSWER: W) LIPID RAFTS ARE MORE LOOSELY PACKED THAN THE SURROUNDING BILAYER

BONUS

3) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are conducting research on light dark matter. Identify all of the following 3 statements regarding light dark matter that is true: 1) Light dark matter is lighter than warm, hot, and cold dark matter; 2) Light dark matter WIMPs have masses of less that 1 GeV; 3) Light dark matter particles are not bounded by the Lee-Weinberg limit because of their extremely high temperature.

ANSWER: 2 ONLY

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TOSS-UP

4) Earth and Space – *Short Answer* In many stars, energy is radiated in the form of photons and neutrinos. What similar process, which occurs within neutron stars and white dwarfs, emits neutrinos and causes a rapid disappearance of thermal energy from the interior of a star?

ANSWER: URCA PROCESS

BONUS

4) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding chinook winds that are true: 1) Temperature drastically falls in areas that chinook winds have recently moved through; 2) Compressional heating provides the internal warmth for a chinook; 3) The appearance of a foehn wall is a telltale sign of an impending chinook.

ANSWER: 2 AND 3
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TOSS-UP

5) Math – *Multiple Choice* A particle moves along a horizontal line, and its position can be determined by the function f of x equals x cubed minus 4 x squared minus 28 x. What is the velocity of the particle at x=4 seconds?

W) -24
X) -12
Y) 12
Z) 24

ANSWER: X) -12

BONUS

5) Math – *Short Answer* Given the function f of x equals x cubed minus 3 x squared minus 10, find the absolute maximum of the function over the interval [2,4].

ANSWER: 6

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following compounds can be produced from Ziegler-Natta catalysts?

W) Alkenes
X) Polymers
Y) Peptides
Z) Acid anhydrides

ANSWER: X) POLYMERS

BONUS

6) Chemistry – *Short Answer* What is the relationship between (E)-2-butene and (Z)-2-butene?

ANSWER: DIASTEREOMERS
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TOSS-UP

7) Physics – *Short Answer* A current of 33 megaamperes is sent through a straight wire 3 meters under a laptop. Assuming that vacuum permeability is $4\pi \times 10^{-7}$, and giving your answer in teslas rounded to the nearest tenth, what is the magnitude of the magnetic field that the laptop is exposed to from the wire?

ANSWER: 2.2

BONUS

7) Physics – *Multiple Choice* Jebediah is on a spacecraft that has just entered the sphere of influence of the moon from an elliptical orbit around Earth. The spacecraft is currently traveling in front of the moon. Which of the following is true about the spacecraft's orbit assuming that no external forces alter the current orbit?

W) The spacecraft will re-enter an elliptical orbit around Earth
X) The spacecraft will continue orbiting around the moon
Y) The spacecraft will fly out of the sphere of influence of Earth
Z) The spacecraft will fly out of the solar system

ANSWER: W) THE SPACECRAFT WILL RE-ENTER AN ELLIPTICAL ORBIT AROUND EARTH

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TOSS-UP

8) Biology – *Multiple Choice* In orchids, which of the following specific types of parasitic symbiosis always occurs at some point of their life stage and is characterized by orchids getting all or part of its food from fungi rather than from photosynthesis?

W) Hemiparasitism
X) Holoparisitism
Y) Adelphoparasitism
Z) Myco-heterotrophism

ANSWER: Z) MYCO-HETEROTROPHISM

BONUS

8) Biology – *Short Answer* In yeasts and mammalian cells, the SNARE proteins mediate the fusion of vesicles with the target membrane. During membrane fusion, what 2 SNARE proteins located on separate membranes combine to form a trans-SNARE complex?

ANSWER: V-SNARE AND T-SNARE
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TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following groups of minerals do NOT have a silicon-oxygen tetrahedron structure?

W) Clay minerals
X) Amphiboles
Y) Sulfides
Z) Micas

ANSWER: Y) SULFIDES

BONUS

9) Earth and Space – *Short Answer* In deep-water nekton, many are specifically adapted to the deep-water environment. What is the name of the active camouflage used by some marine animals that allows them to produce light to match their backgrounds in brightness and wavelength?

ANSWER: COUNTERILLUMINATION

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TOSS-UP

10) Math – *Short Answer* Let f be a differentiable function such that f of 4 equals 10 and f prime of 4 equals negative 6. What is the approximation for f of 4.1 found by using the line tangent to the graph of f at x equals 4?

ANSWER: 9.4

BONUS

10) Math – *Short Answer* Evaluate the integral from 0 to 2 of the function f of x equals the floor of x.

ANSWER: 1

11) Physics – *Short Answer* If a deuterium nucleus resonates at 450 megahertz in a field strength of 4.8 teslas, at what frequency, in megahertz, will the same deuterium nucleus resonate at a field strength of 16.8 teslas?
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TOSS-UP

ANSWER: 1575

BONUS

11) Physics – *Multiple Choice* A 5-meter-long solenoid has 1500 coils of wire and carries a current of 4 amps. Given that the permittivity of free space is 1.25 times 10 to the negative 6, which of the following is the strength of the magnetic field at the center of the solenoid, in teslas?

W) 0.15
X) 0.015
Y) 0.0015
Z) 0.00015

ANSWER: Y) 0.0015

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Brookhaven National Lab are researching new semiconductor designs which scale down better than traditional semiconductors. Traditional semiconductors only work under which of the following conditions?

W) When the entropy of the semiconductor is above 5
X) When the heat of the semiconductor is below 40 celsius
Y) The correspondence limit
Z) When the force exerted on the semiconductor is below 500 newtons

ANSWER: Y) THE CORRESPONDENCE LIMIT

BONUS

12) Energy – *Short Answer* Researchers at Ames National lab have been studying the momentum and spin-dependent splitting of electronic bands in metal halide perovskites. The principle for angular momentum in particles can be derived from what other principle?

ANSWER: HEISENBERG'S UNCERTAINTY PRINCIPLE
13) Biology – *Multiple Choice* Which of the following thick skin epidermis layers is the deepest layer of the epidermis and bonds to the dermis via intertwining fibers of collagen?

W) Stratum spinosum
X) Stratum basale
Y) Stratum granulosum
Z) Stratum corneum
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TOSS-UP

ANSWER: X) STRATUM BASALE

BONUS

13) Biology – *Multiple Choice* Which of the following toll-like receptor cells are located on immune cell plasma membranes and are responsible for recognizing lipopolysaccharides present on the surface of many gram-negative bacteria?

W) TLR3
X) TLR4
Y) TLR7
Z) TLR9

ANSWER: X) TLR4

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TOSS-UP

14) Earth and Space – *Short Answer* What is the name of the dimmest part of Jupiter's rings that is produced by dust particles orbiting near small moons?

ANSWER: GOSSAMER RINGS

BONUS

14) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding starburst galaxies that are true: 1) Starburst galaxies are characterized by extremely low rates of star formation; 2) Galaxies will become starburst galaxies at near the end of their lives, occupying a long period of a galaxy's life; 3) Starburst galaxies are generally red or orange because of the old stars that make up the galaxy.

ANSWER: NONE OF THEM
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TOSS-UP

15) Math – *Short Answer* What is the average value of x cubed over the interval [0,2]?

ANSWER: 2

BONUS

15) Math – *Short Answer* What is the area between the curve f of x equals 25 minus x squared and the x axis?

ANSWER: 500/3 (ACCEPT: 166 AND 2/3)

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TOSS-UP

16) Chemistry – *Multiple Choice* What is the role of the acid catalyst in the Fischer Esterification reaction of ethanol and propanoic acid?

W) Shifts equilibrium to the right
X) Converts ethanol to a more reactive nucleophile
Y) Converts propanoic acid to a more reactive electrophile
Z) Neutralized the base formed in the reaction

ANSWER: X) CONVERTS ETHANOL TO A MORE REACTIVE NUCLEOPHILE

BONUS

16) Chemistry – *Short Answer* What event describes how axial d-orbitals of central metal ions attain a higher energy level while non-axial d-orbitals of CMA attain a lower energy level?

ANSWER: CRYSTAL FIELD SPLITTING
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TOSS-UP

17) Energy – *Short Answer* Researchers at Argonne National Lab have been studying fluid flow in engines that utilize liquid fuel. What is the name of the fundamental equation of fluid dynamics?

ANSWER: NAVIER-STOKES EQUATION (ACCEPT: NAVIER-STOKES)

BONUS

17) Energy – *Multiple Choice* Researchers at Thomas Jefferson National Lab have been using photons to probe the inner structure of protons. Which of the following is true about photons?

W) Photons have three possible polarization states
X) Photons do not obey the Pauli exclusion principle
Y) Photons have a non-zero lepton number
Z) Photons participate in the weak interaction along with mediating it

ANSWER: X) PHOTONS DO NOT OBEY THE PAULI EXCLUSION PRINCIPLE

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TOSS-UP

18) Biology – *Short Answer* Rhizobacteria are bacteria that live in plant roots or in the rhizosphere. What class of rhizobacteria relationship consists of PGPRs that colonize the surface of a plant roots or intercellular spaces of the host plant?

ANSWER: ENDOPHYTIC RELATIONSHIP

BONUS

18) Biology – *Short Answer* In long bones, what is the name of the tubular shaft of compact bone that contains the medullary cavity and yellow bone marrow?

ANSWER: EPIPHYSIS
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TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the astronomical objects that emit bursts of hard x-rays and soft gamma-rays and are thought to closely resemble magnetars?

ANSWER: SOFT GAMMA REPEATER

BONUS

19) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding meteors that are NOT true: 1) Sporadic meteors are meteors that brightly flash within meteor showers; 2) Fireballs are extremely bright meteors that reach up to apparent magnitudes of -15; 3) Chondrites and achondrites make up the smallest majority of meteorites that fall to Earth.

ANSWER: ALL OF THEM

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TOSS-UP

20) Math – *Multiple Choice* Which of the following integrals most accurately describes the volume of y equals x when rotated about the y axis?

W) 2pi times the integral of x squared dx
X) pi times the integral of 2x dx
Y) 2pi times the integral of 2x dx
Z) pi times the integral of x squared dx

ANSWER: Z) PI TIMES THE INTEGRAL OF X SQUARED DX

BONUS

20) Math – *Short Answer* What is the integral of the function f of x equals the quantity 2 x plus 2, times e to the power of x squared plus 2x plus 3?

ANSWER: E TO THE POWER OF THE QUANTITY X SQUARED PLUS 2 X PLUS 3
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TOSS-UP

21) Physics – *Multiple Choice* Which of the following degrees of precision are not possible?

W) Determining the exact length of a ruler down to 10^{-27} of a meter
X) Determining the exact length of a ruler down to 10^{-35} of a meter
Y) Determining the exact length of a ruler down to 16^{-31} of a meter
Z) Determining the exact length of a ruler down to 10^{-33} of an inch

ANSWER: X) DETERMINING THE EXACT LENGTH OF A RULER DOWN TO 10^{-35} OF A METER

BONUS

21) Physics – *Short Answer* There are 18 microstates possible in a system. Giving your answer in percent rounded to the nearest whole number, what is the probability that the 2nd microstate will occur?

ANSWER: 5 (ACCEPT: 6)

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TOSS-UP

22) Chemistry – *Multiple Choice* In a Markovnikov addition to form alcohols from alkenes, which of the following substances would most likely be a reactant?

W) Methyl propanoate
X) Carbonic acid
Y) Zinc oxide
Z) Mercury acetate

ANSWER: Z) MERCURY ACETATE

BONUS

22) Chemistry – *Short Answer* Identify all of the following 3 statements that are true regarding the molecular structure of allene; 1) The molecular geometry of the central atom is linear; 2) All hydrogen atoms are in the same plane; 3) The hybridization of terminal carbon atoms is sp 2.

ANSWER: 1 AND 3 (ACCEPT: ALL BUT 2)
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TOSS-UP

23) Biology – *Short Answer* What is the name of the hypothesized hormone-like molecule produced in plant leaves that is responsible for controlling and triggering flowering in plants?

ANSWER: FLORIGEN

BONUS

23) Biology – *Short Answer* What membrane-bound organelles are responsible for sorting endocytosed material in eukaryotic cells?

ANSWER: ENDOSOMES