

780 Multiple-Choice Questions for Physical Science:

These multiple choice questions are most suited for grades 9-12, but could be used in grades 6-8 with advanced students. Answers are given in blue text. The questions are unnumbered for easier incorporation into your materials. Just copy and paste selected questions into your test document.

Some historical questions are included. That content may not be covered in your text, but it makes a great take-home assignment for online research. These questions were developed for the course Harvard Project Physics. HPP introduced the scientists behind the science, and how they used the scientific method. The course starts with astronomy, using it to show examples of the scientific method in action, how science corrects and updates its theories, and how scientific models evolve.

All questions are "classroom tested" and have been revised as needed to resolve clarity issues and minimize arguments about the right answer. The answer key is guaranteed correct.

A calculator will be required to answer some of the questions.

The following topics are included:

- Page 02: Astronomy (133 questions)
- Page 17: Significant Figures (18 questions, with graphics)
- Page 19: Kinematics (56 questions)
- Page 26: Dynamics (85 questions)
- Page 36: Gravity (35 questions)
- Page 40: Vectors-1 (27 questions, text only)
- Page 43: Vectors-2 (20 questions, with graphics)
- Page 48: Impulse & Momentum (37 questions)
- Page 53: Work & Energy (36 questions)
- Page 57: Kinetic Theory (52 questions)
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ASTRONOMY (133 QUESTIONS):

The first *heliocentric* theory was proposed in the 3rd century BC by which Greek astronomer?

- a. Eudoxus
- b. Aristarchus
- c. Ptolemy
- d. Aristotle

Which of the following was not a reason for the early emergence of astronomical science?

- a. navigation
- b. natural curiosity
- c. communication
- d. survival

Ptolemy published his geocentric theory of celestial motions in the work titled

- a. *Almagest*.
- b. *Celesto Omnibus*.
- c. *Geocentrus*.
- d. *Omniscient Magnificat*.

Which of the following objects moves (consistently) most *slowly* through the sky?

- a. Moon
- b. Sun
- c. Sirius
- d. Mars

When the Sun is rising, the ? Moon must be setting.

- a. 1st Quarter
- b. Full
- c. 3rd Quarter
- d. New

Solar eclipses can only occur during the ? Moon.

- a. 1st Quarter
- b. Full
- c. 3rd Quarter
- d. New

Two of the four seasons last longer than the others. Which two are *longer*?

- a. Spring & Summer
- b. Summer & Fall
- c. Fall & Winter
- d. Winter & Spring

Near the North and South Pole the Sun can sometimes be seen for 24 consecutive hours. What is the name of this amazing phenomenon?

- a. anti-eclipse.
- b. solar epicycle.
- c. midnight Sun.
- d. dark noon.

In what year was the Julian Calendar established?

- a. 372 BC
- b. 45 BC
- c. 0
- d. 1582 AD

Which geometric device did Ptolemy use to account for the retrograde motion of planets?

- a. equant
- b. eccentric
- c. epicycle
- d. protractor

Last night the Moon was 6° west of a star. Where will it be (with respect to that star) at the same time tonight?

- a. 2° east
- b. 6° east
- c. 7° east
- d. 18° west

Which phase of the Moon is directly overhead at sunrise?

- a. Full
- b. 1st Quarter
- c. New
- d. 3rd Quarter

Which of the following does not necessarily occur at the time of solar noon?

- a. clocks read 12:00 pm
- b. shadows are shortest for the day
- c. Sun crosses the true North-South line
- d. Sun is at highest point on ecliptic

How many days are there in a "Julian Year"?

- a. 360
- b. 365
- c. 365.25
- d. 365.24220

What is *parallax*?

- a. shift in position of a moving object
- b. apparent shift in the observer's location due to his apparent motion
- c. apparent shift of an observed object due to observer motion
- d. shift in the observer's apparent position due to his own motion

How many degrees of the ecliptic are visible during Winter?

- a. 180
- b. < 180
- c. > 180
- d. It depends on the hemisphere in which the observer is located.

The time is midnight. The Moon is just rising. Its phase is

- a. New.
- b. 1st Quarter.
- c. Full.
- d. 3rd Quarter.

The time is noon. The Moon is just rising. Its phase is

- a. New.
- b. 1st Quarter.
- c. Full.
- d. 3rd Quarter.

The time is dawn. The Moon is just setting. Its phase is

- a. New.
- b. 1st Quarter.
- c. Full.
- d. 3rd Quarter.

The time is midnight. The Moon is overhead. Its phase is

- a. New.
- b. 1st Quarter.
- c. Full.
- d. 3rd Quarter.

At latitudes above the arctic circle it is possible to experience 24 consecutive hours of daylight, an astounding phenomenon known as the

- a. [midnight sun](#).
- b. solar retrograde.
- c. anti-eclipse.
- d. diurnal opposition.

Which of the following is not a necessary characteristic of a scientific model? It must

- a. [look like what it models](#).
- b. react to input and output as does what it models.
- c. be the simplest of all possible alternative models.
- d. allow new insights, predictions, and understandings.

What was the main argument against early heliocentric models?

- a. Stars did not undergo the predicted brightness variations.
- b. [Stellar parallax could not be observed](#).
- c. They violated Plato's "circular motion" assumption.
- d. Retrograde motion was extremely complicated in these models.

Which of the following was not a motivation for early interest in celestial motions?

- a. association of the heavens with the gods
- b. [experimental testing of Euclid's new geometry](#)
- c. seasonal patterns of growth and migration
- d. long distance travel and navigation

The most accurate and complex *geocentric* model of the heavens was proposed by

- a. Aristotle.
- b. [Ptolemy](#).
- c. Aristarchus.
- d. Plato.

What is the maximum angular distance between Venus and the Sun?

- a. 14°
- b. 26°
- c. 32°
- d. [48°](#)

Who established the calendar in current (western) use?

- a. Julius Caesar
- b. [Pope Gregory](#)
- c. Thomas Aquinas
- d. Ibn Rashd

Which of the following is not a constellation?

- a. Orion
- b. Sirius
- c. Ursa Major
- d. Cassiopeia

Which of the following is the correct order for celestial bodies in a *geocentric* model?

- a. Earth / Moon / Mars / Venus
- b. Earth / Moon / Sun / stars
- c. Earth / Sun / Moon / stars
- d. Earth / Sun / Venus / Saturn

If the star Sirius rose at 10:00 pm last night, what time will it rise tonight?

- a. 9:10 pm
- b. 9:56 pm
- c. 10:04 pm
- d. 10:50 pm

If the Moon rose at 9:00 pm last night, what time will it rise tonight?

- a. 8:10 pm
- b. 8:56 pm
- c. 9:04 pm
- d. 9:50 pm

The Full Moon rose at 9:00 pm. At what time did the Sun set?

- a. 6:00 pm
- b. 7:00 pm
- c. 8:00 pm
- d. 9:00 pm

The moon is 10° east of a star tonight. Where will it be (with respect to that star) at the same time tomorrow?

- a. 2° west
- b. 13° west
- c. 12° east
- d. 23° east

If the Moon was just setting at 8pm yesterday, where will it be tonite at 8pm?

- a. just rising
- b. 12° above the western horizon
- c. due south
- d. below the horizon

The elevation of Polaris above the horizon is primarily a function of the observer's

- a. latitude.
- b. longitude.
- c. local solar time.
- d. It is a function of all the above.

Which of the following is not true of the Moon's phase cycle?

- a. Within any cycle, "first quarter" follows "waxing crescent".
- b. Its period is approximately 30 days.
- c. The darkened portion is caused by the Earth's shadow.
- d. The illuminated portion is caused by the Sun's light.

Which of the following is accompanied by both a southward movement of the ecliptic, and a 1:1 day-to-night ratio?

- a. winter solstice
- b. vernal equinox
- c. summer solstice
- d. autumnal equinox

If the Moon is at "3rd quarter", where will it be seen by an observer at noon?

- a. directly overhead
- b. on the western horizon
- c. on the eastern horizon
- d. It could not be seen at all under these conditions.

Which of the following is not an apparent motion of the Sun?

- a. daily westward motion across the sky
- b. yearly eastward motion with respect to the stars
- c. clockwise rotation with a period of about 44 days
- d. seasonal north-south drift on the ecliptic

Which of the following is an impossible position for Mercury?

- a. rising one hour before the sun
- b. setting three hours after the sun
- c. visible above the horizon four hours after sunrise
- d. staying below the horizon one hour before sunset

Aristarchus proposed that planetary retrograde motion was an effect caused by

- a. the Earth's motion around the Sun.
- b. gravitational attraction by dark matter.
- c. tilting of the solar system's center of mass.
- d. friction between the crystalline spheres.

Which of the following was not a reason for the enduring belief in Ptolemy's geocentric model? It

- a. agreed with common sense and intuition.
- b. predicted celestial motions with reasonable accuracy.
- c. was complimentary to most details of Greek philosophy.
- d. allowed for violent forces capable of moving the Earth.

Which of the following is not true for a planet at "opposition"? It will be

- a. brightest.
- b. rising at midnight.
- c. retrograding.
- d. 90 degrees from the Sun.

What northern hemisphere event is marked by the farthest southward position of the ecliptic?

- a. winter solstice
- b. vernal equinox
- c. summer solstice
- d. autumnal equinox

Which of the following occurs during a total solar eclipse?

- a. The Moon moves into the shadow of the Earth.
- b. The Earth and Moon are on opposite sides of the Sun.
- c. The Moon becomes dark on both sides.
- d. The Sun and Moon align in the sky as seen from Earth.

Which of the following is a possible location for the planet Mercury?

- a. on the ecliptic and 12° from the Sun
- b. 10° north of the ecliptic and 20° west of the Sun
- c. 5° south of the ecliptic and 30° east of the Sun
- d. 50° north of the ecliptic and East of the Sun

If the Moon had a period of 30 minutes (instead of 30 days) it would

- a. move from north to south across the sky.
- b. rise in the west instead of the east.
- c. never produce eclipses.
- d. be "full" only when located between the Sun and Earth.

Mars is at azimuth 180° (south). On average, it will set in the west in ? hours.

- a. 6
- b. 12
- c. 15
- d. 24

In order to account for the observed motions of the Sun, any heliocentric theory must include an Earth that both

- a. retrogrades and tilts.
- b. oscillates and nutates.
- c. rotates and revolves.
- d. accelerates and decelerates.

If the Moon rose at 10 pm today, then it will rise at ? pm tomorrow.

- a. 9:10
- b. 10:00
- c. 10:50
- d. 11:00

If Sirius rose when the Sun set last night, then it will be visible at night for next ? days.

- a. 30
- b. 90
- c. 180
- d. 365

If Mercury is currently 15 degrees west of the Sun, then it will rise ? before the Sun.

- a. 1 minute
- b. 15 minutes
- c. 1 hour
- d. 15 hours

If there was a full Moon last night, then the First Quarter phase will occur in ? days.

- a. 7.5
- b. 15
- c. 22.5
- d. 30

Which of the following is a constellation of the Zodiac?

- a. Cassiopeia
- b. Orion
- c. Lyra
- d. Gemini

The "parallax counter-argument" used against the heliocentric theories was based on

- a. retrograde motion of the Sun during equinoxes.
- b. lack of an observable annual shift in the positions of stars.
- c. nonconvergence of planetary azimuths.
- d. failure of the long-trusted Euclidean parallel postulate.

What social phenomenon was occurring in Europe at the time that Copernicus proposed his bold new idea: the Heliocentric Theory?

- a. exploration of the "New World"
- b. Renaissance
- c. Reformation
- d. All of the above were occurring around this time.

Which of the following was not an accomplishment of Tycho Brahe?

- a. accumulation of celestial position data to unprecedented accuracy
- b. construction of large, high precision calibrated instruments
- c. correction of data for the effect of light refraction in the atmosphere
- d. production of high quality astronomical lenses and mirrors

The retrograde motion of planets is due to

- a. the gravitational influences of Dark Matter.
- b. our observing them from a moving frame of reference.
- c. epicycles embedded in the celestial sphere.
- d. the slightly noncircular shape of all their orbits.

Tycho Brahe discovered that comets were

- a. actually meteorological phenomena inside the Earth's atmosphere.
- b. many times more distant than the Moon.
- c. made of ice and dust congealed in the depths of space.
- d. originating somewhere outside the orbit of Pluto.

The title of the work in which Copernicus published his Heliocentric Theory was

- a. Principia Mathematica.
- b. Almagest Debunkus.
- c. De Revolutionibus Orbium Coelestium.
- d. Uraniborg et Dei Platonium.

The lack of observable stellar parallax was explained by heliocentrists as being due to the

- a. very great distances to the stars.
- b. gyroscopic stability of the rotating Earth.
- c. faster motion of planets nearer the Sun.
- d. concentric motion of the celestial sphere.

Select the set of planets correctly ordered by *increasing* distance from the Sun.

- a. Mercury, Earth, Mars, Venus
- b. Venus, Mars, Saturn, Mercury
- c. Earth, Mars, Jupiter, Neptune
- d. Mars, Jupiter, Uranus, Saturn

Which celestial model is used by navigators of Earth's oceans?

- a. Oceanocentric
- b. Geocentric
- c. Heliocentric
- d. Galactocentric

What was the name of Tycho's observatory?

- a. Fredericksdome
- b. Uraniborg
- c. Neptunalot
- d. Brahe's Tower

Which of the following was not an advantage of Copernicus' Heliocentric Theory over its Geocentric competitors? It was

- a. more accurate.
- b. backed by physical explanations.
- c. proposed during the Renaissance.
- d. quantified with real data.

Which great English poet wrote about the Helio- vs. Geocentric controversy in an epic poem titled "Paradise Lost"?

- a. Cleese
- b. Cervantes
- c. Milton
- d. Shakespeare

How did Copernicus explain the constant tilt of Earth's rotation axis as it moved through space?

- a. attraction by the star Polaris
- b. gravitational spin-coupling with Mars and Venus
- c. gyroscopic stability
- d. more weight of water in the southern hemisphere

Which group was responsible for the dissemination throughout Europe of most astronomical knowledge originally archived in the Great Library at Alexandria?

- a. Greeks
- b. Nerds
- c. Muslims
- d. Transcendentalists

What celestial event is marked by a southward drift of the ecliptic and equal periods of daylight and darkness?

- a. Winter Solstice
- b. Vernal Equinox
- c. Summer Solstice
- d. Autumnal Equinox

Which feature of the Geocentric theory's *epicycles* was a clue to Copernicus that the Earth moved through space? Epicycles

- a. had a period of 1 year.
- b. were all in the same direction.
- c. tilted with respect to the Sun.
- d. All of the above were clues.

Which of the following would be a valid reason for rejecting one of two otherwise equal competing scientific theories?

- a. It is not expressed mathematically.
- b. The theory's models cannot be physically constructed.
- c. It does not agree with what common sense would tell you.
- d. The theory is the more complex, and requires more assumptions.

The rotation axis of the planet Uranus lies in its plane of orbit. If an observer on the north pole of Uranus watches the Sun from Summer Solstice to Winter Solstice, it would

- a. move along a straight line from south to north.
- b. spiral around the horizon, in ever tightening circles, toward the zenith.
- c. trace a sine-wave pattern back and forth from east to west.
- d. disappear from the sky after the Autumnal Equinox.

Which of the following planets is farthest from the Sun?

- a. Mercury
- b. Earth
- c. Mars
- d. Jupiter

Who did Tycho Brahe hire to assist with his data analysis?

- a. Isaac Newton
- b. Galileo Galilei
- c. Johannes Kepler
- d. Nicolas Copernicus

What is the approximate length of one (1) AU?

- a. 10,000,000 miles
- b. 100,000,000 miles
- c. 1,000,000,000 miles
- d. 10,000,000,000 miles

Which of the following are modern-day observatories?

- a. Palomar
- b. Kitt Peak
- c. Cerro Tollolo
- d. All of the above are modern-day observatories.

Which of the following is not one of the features of Copernicus' heliocentric theory? The Earth

- a. revolves around the Sun.
- b. rotates on its polar axis.
- c. is a planet.
- d. retrogrades once every opposition.

Which of the following was not a part of Tycho's compromise helio-geocentric model?

- a. The Earth was fixed in space.
- b. The planets (except for Earth) revolved around the Sun.
- c. The Sun revolved around the Earth.
- d. The sun was at the center of the universe.

Which of the following planets is closest to the Sun?

- a. Mars
- b. Saturn
- c. Venus
- d. Earth

Which of the major European religions agreed with Copernicus' Heliocentric theory?

- a. Catholicism
- b. Judaism
- c. Protestantism
- d. None of them agreed with Copernicus.

Which of the following was not an argument used against the heliocentric theory?

- a. No annual parallax shift was observed in the stars.
- b. The "moving Earth" violated Aristotelian physics.
- c. Its predictions failed Plato's accuracy criteria.
- d. It conflicted philosophically with religious teachings.

In Copernicus' model, what was the period of motion of Mars?

- a. 0.7 years
- b. 1.5 years
- c. 1.88 years
- d. 12.1 years

In Copernicus' model, what was the period of motion of Saturn?

- a. 15.8 years
- b. 19.2 years
- c. 24.5 years
- d. 29.4 years

In Copernicus' model, what was the orbital radius of Venus?

- a. 0.27 AU
- b. 0.38 AU
- c. 0.72 AU
- d. 0.83 AU

In Copernicus' model, what was the orbital radius of Jupiter?

- a. 1.52 AU
- b. 3.74 AU
- c. 5.20 AU
- d. 8.22 AU

In Copernicus' model, what was the orbital radius of Mars?

- a. 0.72 AU
- b. 0.94 AU
- c. 1.22 AU
- d. 1.52 AU

Why can one not visit Tycho's observatory today?

- a. It was moved to a country now under communist rule.
- b. The area has been classified as off-limits to tourists.
- c. The Huns burned it to the ground and stole the instruments.
- d. It was destroyed during the "Thirty Years War."

Copernicus' and Ptolemy's models both predicted the positions of celestial objects to an accuracy of approximately +/-

- a. 0.5 degrees.
- b. 1 degree.
- c. 2 degrees
- d. 5 degrees.

What did the appearance of a "nova" suggest to Tycho Brahe?

- a. The heavens were not as unchanging as the ancients had taught.
- b. Stars do not last forever and can occasionally explode.
- c. Geocentrism cannot be correct since novae are unpredictable.
- d. The daytime sky is filled with stars just like at night.

Copernicus was able to obtain the planets' relative orbital radii through the methods of

- a. graphic extrapolation.
- b. Doppler radar analysis.
- c. plane geometry.
- d. celestial calculus.

Why, in Copernicus' view, did all celestial bodies appear to move at a speed of nearly 15 deg/hr?

- a. All celestial bodies are held together by the force of gravity.
- b. The Sun dominates all celestial motion, and that is its speed.
- c. The Earth itself was rotating at about 15 degrees/hour.
- d. There was no real reason. He felt it was a coincidence.

The planet Venus will be at its "greatest elongation" when

- a. it is farthest from the Sun, as measured in units of AU.
- b. the Sun's gravity stretches it by the maximum amount.
- c. a line of sight from the Earth to Venus is tangent to its orbit.
- d. it is moving most rapidly, as seen from the Earth.

Which of the following planets was not included in Copernicus' heliocentric model?

- a. Mercury
- b. Mars
- c. Saturn
- d. Neptune

About how far is it from Earth to the nearest star?

- a. 200 AU
- b. 20,000 AU
- c. 200,000 AU
- d. 20,000,000 AU

Which two books were published by Kepler to present his laws of planetary motion?

- a. *Astronomia Nova* and *Harmony of the World*
- b. *Two Chief World Systems* and *Astronomia Nova*
- c. *The Starry Messenger* and *Two Chief World Systems*
- d. *Harmony of the World* and *The Starry Messenger*

Galileo's telescopic observations included all of the following *except*

- a. the phases of Venus
- b. galaxies beyond the Milky Way
- c. four moons of Jupiter
- d. sunspots

Why, 15 centuries after the first heliocentric theory was proposed, did Copernicus' theory meet with general acceptance?

- a. Physical proof of heliocentrism finally existed.
- b. Society in the 1600's was more open to new attitudes and ideas.
- c. The church was now willing to support heliocentrism.
- d. It didn't. It was rejected by just about everybody.

The *Platonic Solids* were

- a. a group of intellectuals who supported Plato and rejected heliocentrism.
- b. celestial crystals formed by slowly cooling Platonic liquids.
- c. geometric figures used by Kepler to ascertain the planets' relative orbital radii.
- d. strange, regular markings observed on the lunar maria.

If a planet had an orbital eccentricity equal to 1.0, then it would necessarily

- a. orbit perpendicular to the plane of solar precession.
- b. collide with the Sun before completing a single orbit.
- c. escape from the system on a hyperbolic path.
- d. be imaginary, since all orbits have $e > 1$.

Around what year did Galileo first turn his telescope on the heavens?

- a. 1400
- b. 1500
- c. 1600
- d. 1700

In what book did Galileo publish his 6 telescopic discoveries?

- a. Sirius Nonesuch
- b. Two Chief World Systems
- c. The Starry Messenger
- d. Sagredo's Travels

Galileo's telescopic observations showed that the planets were

- a. not really wanderers.
- b. frequently outside the limits of the Zodiac.
- c. exactly like stars, but much closer.
- d. physical places like the Earth.

Kepler's analysis of the orbit of _?_ showed that planets moved in elliptical paths.

- a. Mercury
- b. Venus
- c. Earth
- d. Mars

The Aristotelian objection to Copernicus' explanation for the lack of observable stellar parallax was that:

- a. "great amounts of nothingness cannot possibly exist in Nature."
- b. "a moving Earth would throw its inhabitants into space."
- c. "no force could ever be large enough to move the Earth."
- d. "Man's proper place in the Universe was at its center."

If the foci of an orbit were coincident (at the same place), then the orbit would be

- a. circular.
- b. perpendicular.
- c. such that $e = 0.5$.
- d. unstable.

Plato, Galileo, Marx and Huxley knew that if a government wants to control its people it must

- a. levy taxes.
- b. set up national borders.
- c. control the emergence of new ideas.
- d. rule in a just and consistent manner.

Which of the following is *false* for all elliptical orbits?

- a. $v_p > v_a$
- b. $a > b$
- c. $T > 0$
- d. $c > a$

Orbits with high eccentricity will also have a larger

- a. period.
- b. speed variation.
- c. planet.
- d. area.

Kepler's view of celestial motion was that it was like (in his words)

- a. "chaotic randomness".
- b. "a clockwork mechanism".
- c. "perfection of circles".
- d. "choreographed quintessence".

Kepler's Laws of Planetary Motion were *empirical*. This means that they were

- a. almost certainly correct.
- b. contradictory to intuition.
- c. based on observational data.
- d. derived solely from geometry.

One *Astronomical Unit* (AU) is a distance approximately equal to

- a. 0.93 million miles.
- b. 9.3 million miles.
- c. 93 million miles.
- d. 930 million miles.

Kepler published his discovery of elliptical orbits in a work titled

- a. Dioptrice.
- b. Ptolemaeus Debunkus.
- c. Platonicus Solidus.
- d. *Astronomia Nova*.

Tycho Brahe measured the accuracy of his instruments and noted adjustments needed to be made to improve the accuracy of their readings. This process is known as

- a. extrapolation.
- b. interpolation.
- c. regimentation.
- d. calibration.

Which of the following was not a telescopic discovery made by Galileo?

- a. Venus' phases
- b. Jupiter's satellites
- c. sunspots
- d. lunar rotation

Kepler discovered the physical law relating a planet's

- a. mass and orbital speed.
- b. orbital radius and orbital inclination.
- c. period of revolution and orbital radius.
- d. orbital speed and orbital period.

Which of the following planets was not known in Kepler's time?

- a. Neptune
- b. Mercury
- c. Saturn
- d. Mars

Which of the following was not an advantage of Copernicus' heliocentric theory over the geocentric theories?

- a. There was physical proof of its correctness.
- b. It had a scale of distances built into it.
- c. Objections to it were met by logical counter-arguments.
- d. It was a geometrically simpler model.

Galileo's telescopic observations caused him to

- a. believe more strongly yet in the heliocentric theory.
- b. seriously consider the correctness of Tycho's model.
- c. renounce his belief that the Earth orbited the Sun.
- d. revise his estimates of the inter-focal distances.

Kepler came to work for Tycho at the observatory called

- a. Jupitiborg.
- b. Saturborg.
- c. Uraniborg.
- d. Neptuborg.

Kepler used the Platonic Solids in his astronomical research as

- a. models for the planets' relative orbital radii.
- b. supporting structures for his telescopes.
- c. mechanical devices that simulated retrograde motion.
- d. tools for generating random elliptical curves.

What mathematical tool did Kepler use to speed his computations.

- a. adding machine
- b. logarithms
- c. random number tables
- d. Cyber 5000 digital computer

Which of the following is not one of the conic sections?

- a. parabola
- b. ellipse
- c. tetrahedron
- d. hyperbola

Kepler's published chart of predicted planetary motions was known as the

- a. Almagest.
- b. Rudolphine Tables.
- c. Ephemeris Novus.
- d. Review of Celestial Motion.

What did Kepler think kept the planets moving in their orbits?

- a. inertia
- b. gravity
- c. magnetism
- d. He had no idea. His model was purely kinematic.

Galileo's telescopic survey of the Moon showed that it

- a. was not a perfect sphere.
- b. had geological features much like parts of the Earth.
- c. experienced day, night, shadow and light.
- d. All of the above are included in his findings.

Celestial navigation is based on a book of charts showing the positions of stars, planets, Moon and Sun. Such a book is called an

- a. astronomical encyclopedia.
- b. ephemeris.
- c. actuarial plotter.
- d. atlas de Copernicus.

Tycho Brahe made allowances for the refraction of light in his data on the positions of celestial bodies. Refraction of light is the

- a. formation of multiple images due to scattering.
- b. change in a light beam's direction due to the atmosphere.
- c. dimming of brightness over great distances.
- d. change in the color of light caused by water droplets.

In the Dialogues, who was the voice of Galileo?

- a. Salviati
- b. Simplicio
- c. Sagredo
- d. Mrs. Galileo

Galileo reconciled the discoveries of science with religious doctrine by asserting that

- a. scientific discoveries are awarded to those with virtue.
- b. an insight into natural law was a revelation from God.
- c. God and Nature both hide their laws from common view.
- d. scientists, like saints, were considered to be "chosen people".

How many Platonic Solids were known to Kepler?

- a. 5
- b. 6
- c. 7
- d. 8

Any two planets' orbital planes must intersect in a line that passes through the

- a. aphelion.
- b. center of each orbit.
- c. minor axis
- d. Sun.

How did Galileo spend his last years?

- a. on a telescope promotion tour of southern Europe
- b. under house arrest in Florence, Italy
- c. in a position of honor at the Vatican
- d. with Marco Polo in the Far East

If a planet has an average orbital radius of 5 AU, and it is 3 AU from one of its orbital foci when at perihelion, then how far is it from the other focus? You don't need a calculator to answer this.

- a. 2 AU
- b. 7 AU
- c. 8 AU
- d. 15 AU

SIGNIFICANT FIGURES (18 QUESTIONS WITH GRAPHICS):

Precision is to *accuracy* as *_?_* is to *_?_*.

- a. information - correctness
- b. error - truth
- c. measure - estimate
- d. right - wrong

The "least significant datum" rule applies to data that are

- a. added or multiplied.
- b. added or subtracted.
- c. multiplied or divided.
- d. divided or subtracted.

Your car used 25.3 gallons of gas to drive 410.56 miles. What is its MPG?

- a. 16
- b. 16.2
- c. 16.23
- d. 16.228

Round the measurement "204.558 m" to 4 significant figures.

- a. 2045 m
- b. 204.5 m
- c. 204.6 m
- d. 4.558 m

Round the measurement "542.6 m" to 2 significant figures.

- a. 2.6 m
- b. 54 m
- c. 43 m
- d. 5.4×10^2 m

Round the measurement "0.0020549 m" to 2 significant figures.

- a. 0.0 m
- b. 0.0021 m
- c. 0.00205 m
- d. 0.0000059 m

What is the correct sum of X+Y+Z if the data are as shown:

- a. 170.2 g
- b. 170.21 g
- c. 170.214 g
- d. 170.2142 g

X = 123.5 g
Y = 45.26 g
Z = 1.4542 g

If $v = d/t$, and $d = 120$ mi, and $t = 2.0$ hr, then $v = ?$

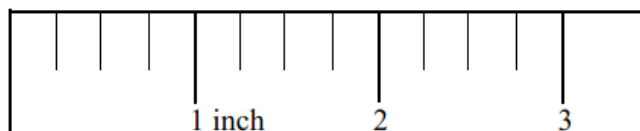
- a. 60.00 mi/hr
- b. 60.0 mi/hr
- c. 60 mi/hr
- d. 6×10^1 mi/hr

What is the precision of an American cash register?

- a. \$1
- b. \$1.00
- c. \$0.01
- d. \$0.00

What is the precision of this ruler?

- a. 0.01 inch
- b. 0.1 inch
- c. 0.25 inch
- d. 0.50 inch



The "last significant place" rule applies to data that are

- a. added or multiplied.
- b. added or subtracted.
- c. multiplied or divided.
- d. divided or subtracted.

What is the precision of the clock for professional track & field events?

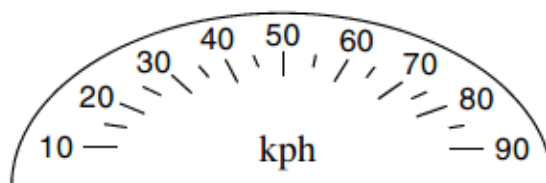
- a. 1 s
- b. 0.1 s
- c. 0.01 s
- d. 0.001 s

How would you express the calculated result of 1000 miles to 2 significant

- a. 1×10^2 miles
- b. 1.0×10^2 miles
- c. 1.0×10^3 miles
- d. 1.00×10^3 miles

What is the precision of this speedometer?

- a. 0.5 kph
- b. 1 kph
- c. 5 kph
- d. 10 kph



Round the measurement 0.001369 to 2 significant figures.

- a. 0.00
- b. 0.0013
- c. 0.0014
- d. 0.1369

What is the correct sum of X+Y+Z if the data are as shown:

- a. 2.77 m
- b. 2.771 m
- c. 2.8 m
- d. 2.801 m

X = 2.5 m
Y = 0.081 m
Z = 0.19

When rounding a number, what do you do with an ending "5"?

- a. Round up if the previous digit is odd.
- b. Round down if the previous digit is even.
- c. Ignore it.
- d. It makes no difference as long as you consistently follow rule "a" or "b".

The more significant figures in a measurement, the

- a. more precise is the measuring instrument.
- b. greater the accuracy.
- c. less chance for error.
- d. fewer random errors will occur.

KINEMATICS (56 QUESTIONS):

Which of the following is not true of strobe photography?

- a. It provides a permanent record of an object's motion.
- b. The moving object is not affected (much) by the measurement.
- c. One can use it to measure the speed of anything that moves.
- d. All of the above are true.

The light source used in strobe photography must do all of the following except

- a. flash at a constant, known rate.
- b. emit enough light to expose film.
- c. produce pure white light.
- d. illuminate the moving object

A strobe photo of a moving object shows distance intervals that continuously increase. Thus,

- a. the object is accelerating.
- b. the strobe flash rate is slowing.
- c. the camera was moving.
- d. All the above are possible explanations.

If a strobe photo of an object shows equal distance intervals between all the images, then you can conclude that the object was

- a. at rest.
- b. moving uniformly.
- c. accelerating.
- d. accelerating non-uniformly.

Which of the following is not a necessary feature on a strobe photo used to measure speed?

- a. multiple images of the moving object
- b. an object of known length, such as a ruler
- c. a clock
- d. a view perpendicular to the direction of motion

The flash of a strobe lamp is fast. The light is only on for about 10 microseconds, i.e., $\Delta t =$

- a. 0.00001 s
- b. 0.000001 s
- c. 0.0000001 s
- d. 0.00000001 s

The process of trying to read values between points plotted on a graph is known as

- a. *estimation*.
- b. *interpolation*.
- c. *extrapolation*.
- d. *integration*.

When an object accelerates uniformly it will

- a. take equal amounts of time to double its acceleration.
- b. have equal changes in speed during equal intervals of time.
- c. move equal amounts of distance in equal intervals of time.
- d. All of the above will occur during uniform acceleration.

The outcome of a race, i.e., who wins and who loses, is decided on the basis of what quantity?

- a. instantaneous speed
- b. average speed
- c. final speed
- d. change in speed

You cover a distance of 12 miles moving at an average speed of 3 mi/hr. Elapsed time =

- a. 0.25 hr
- b. 0.33 hr
- c. 0.50 hr
- d. 4.0 hr

You increase your speed by 20 m/s in a time of 4 seconds. Your rate of acceleration was

- a. 0.5 m/s^2 .
- b. 2 m/s^2 .
- c. 5 m/s^2 .
- d. 80 m/s^2 .

If a distance vs. time graph records those quantities in units of feet and hours, then a plot from (2,3) to (5,9) represents a speed of

- a. 0.5 ft/hr.
- b. 2 ft/hr.
- c. 3 ft/hr.
- d. 6 ft/hr.

On a graph of distance vs. time, deceleration is properly represented by a plot having

- a. increasing positive slope
- b. decreasing positive slope
- c. shortening horizontal slope
- d. All of the above are possible answers.

What is meant by the term *negative acceleration*?

- a. speed is increasing, but ever less rapidly
- b. speed is changing randomly
- c. speed is decreasing
- d. None of the above are correct choices.

You are moving at 20 m/s and decelerate at a rate of 3 m/s^2 for a time of 2 seconds. $V_f =$

- a. 10 m/s.
- b. 14 m/s.
- c. 15 m/s.
- d. 17 m/s.

You are moving at a speed of 4 m/s and accelerate at a rate of $+2 \text{ m/s}^2$ for 5 seconds. $V_f =$

- a. 6 m/s.
- b. 8 m/s.
- c. 14 m/s.
- d. 22 m/s.

On a graph of d vs. t, the slope of a line drawn tangent to the curve at any point equals the

- a. average speed maintained up to that point in time.
- b. acceleration occurring at that instant.
- c. instantaneous speed at that point in time.
- d. area under the curve.

What is the acceleration of a car that goes from 30 mph to 80 mph in a time of 0.25 minutes?

- a. 200 mi/hr/min
- b. 240 mi/hr/min
- c. 360 mi/hr/min
- d. 360 mi/hr/min

Instantaneous speed equals average speed whenever the motion is

- a. in a straight line.
- b. accelerated.
- c. frictionless
- d. uniform.

The accepted abbreviations for "mile", "meter", and "minute" are, respectively,

- a. "m", "m" and "m"
- b. "mi", "m", and "min"
- c. "m", "me", and "min"
- d. "mi", "met", and "m".

To change your running speed from a sprint of 20 ft/s to a jog of 5 ft/s in a time of 3 seconds you must accelerate at a rate of

- a. -3 ft/s^2 .
- b. -5 ft/s^2 .
- c. $+15 \text{ ft/s}^2$.
- d. $+25 \text{ ft/s}^2$.

The process of trying to predict the behavior of data beyond the range measured or plotted is

- a. "estimation".
- b. "interpolation".
- c. "extrapolation".
- d. "integration".

Which of the following conditions are necessary to use the equation " $d = \frac{1}{2}at^2$ "?

- a. $v_o = v_f$
- b. $v_o = 0$
- c. $v_f = a$
- d. $a = 0$

You can walk the 10 miles from home to school in 2 hours. Your walking speed =

- a. 0.2 mph
- b. 2 mph
- c. 5 mph
- d. 20 mph

You can crawl the 2 miles from home to school in 5 hours. Your crawling speed =

- a. 0.2 mph
- b. 0.4 mph
- c. 2.5 mph
- d. 10 mph

The metric abbreviation " μs " (microsecond) represents what fraction of a second?

- a. tenth
- b. hundredth
- c. thousandth
- d. millionth

The area under the curve on a graph of *acceleration* vs. *time* would be numerically equal to the

- a. total distance covered.
- b. elapsed time.
- c. net change in speed.
- d. instantaneous velocity.

On a graph of distance vs. time, the plot climbs with a positive slope, then falls with a negative slope. Your conclusion is that

- a. speed first increased but then decreased.
- b. direction of motion has reversed.
- c. an object is moving in two directions simultaneously.
- d. acceleration was non-uniform.

Which of the following was not a property of Aristotle's "Quintessence"?

- a. extreme heaviness
- b. luminescence (emitted light)
- c. circular motion
- d. never at rest

Which of the following would result in a *decrease* of local " a_g "?

- a. climbing a mountain
- b. walking north
- c. stopping Earth's rotation
- d. None of the above are correct.

Under what conditions is Δv equal to v_{ave} ?

- a. constant speed
- b. uniform acceleration
- c. rest
- d. They are never equal.

According to Aristotle's cosmology, a moving object always came to rest because

- a. that was its natural tendency.
- b. friction was impossible to eliminate.
- c. gravity slowed it down.
- d. other objects absorbed its quintessence.

You walk 2 km north, 5 km east, 3 km south, and 5 km west. Your *displacement* is

- a. 1 km south
- b. 2 km west
- c. 7 km northeast
- d. 15 km southwest

The distinction between *vectors* and *scalars* is that vectors

- a. almost always have greater magnitude.
- b. cannot total to zero.
- c. have a direction.
- d. are always positive.

You drive 3 miles north and 4 miles west. Your displacement is

- a. 5 miles northwest.
- b. 7 miles northwest.
- c. 12 miles northwest.
- d. 34 miles northwest.

You drive 6 miles east, 4 miles north, and 3 miles west. Your displacement is ? northeast.

- a. 72 miles
- b. 13 miles
- c. 5 miles
- d. 1 mile

Which of the following is a *vector* quantity?

- a. temperature
- b. force
- c. volume
- d. time

An object thrown vertically upward with a speed of 100 m/s will, after 12 seconds, have a $v_f =$

- a. 20 m/s.
- b. 80 m/s.
- c. 120 m/s.
- d. 220 m/s.

An object thrown vertically *downward* with a speed of 1 m/s will, after 0.1 s, have a $v_f =$

- a. 1 m/s.
- b. 2 m/s.
- c. 10 m/s.
- d. 11 m/s.

In what country did Galileo perform most of his experiments?

- a. Germany
- b. Italy
- c. France
- d. Turkey

A body dropped vertically from rest will cover ? distance during its first second of fall.

- a. 0 m
- b. 5 m
- c. 10 m
- d. 15 m

Which of the following quantities is *constant* during uniform acceleration?

- a. d^2/t
- b. d/t^2
- c. $(d/t)^2$
- d. $d \times t^2$

Galileo discovered that when a bearing rolls down one ramp, and up another, it will not stop and reverse motion until it regains its original

- a. mass.
- b. slope.
- c. height.
- d. diameter.

Aristotle's law of falling bodies maintained that ? determined the rate of fall.

- a. height
- b. composition
- c. gravity
- d. initial speed

The *area* under the plot of motion on a graph of *speed vs. time* is equal to the

- a. total elapsed time.
- b. average rate of speed.
- c. total distance covered.
- d. instantaneous acceleration.

In Galileo's Dialogues, what character represented the Aristotelian point of view?

- a. **Simplicio.**
- b. Sagredo.
- c. Salviati.
- d. Suchadummio.

In Galileo's Dialogues, what character represented the Galilean point of view?

- a. Simplicio.
- b. Sagredo.
- c. **Salviati.**
- d. Sharpazatackio.

In Galileo's Dialogues, what character played the part of a "neutral observer"?

- a. Simplicio
- b. **Sagredo**
- c. Salviati
- d. Senterstio

Galileo's experiments on gravitational acceleration relied on hardwood ramps, brass bearings and a simple but reliable timekeeping mechanism known as the

- a. hourglass.
- b. **water clock.**
- c. sundial.
- d. human pulse rate.

The goal of Galileo's inclined plane experiments was to

- a. measure the affect of friction on rolling bodies.
- b. **establish that gravity caused uniform acceleration.**
- c. prove that gravity also affects metallic objects.
- d. refute Aristotle's theory of Quintessence.

Which of the following is true statement?

- a. In the absence of gravity, all bodies fall at the same rate.
- b. All bodies fall at constant speed in a vacuum.
- c. Friction causes changes in a body's mass.
- d. **In the absence of friction, all bodies fall with the same acceleration.**

Galileo published his studies of motion in a work titled

- a. Principia Mathematica.
- b. **Two New Sciences.**
- c. Two Great World Systems.
- d. Quintessence Unbound.

Why did Galileo use the equation " $a = 2d/t^2$ " instead of " $a = \Delta v/\Delta t$ " to measure acceleration?

- a. At this time in history it was still impossible to compute "squares" of quantities.
- b. He was still unsure about the meaning of the symbol "A".
- c. The second equation does not apply to freely falling bodies.
- d. **It was easier to measure "d" and "t" than it was to measure " Δv ".**

The best "words only" definition of *uniform acceleration* is

- a. "equal changes in distance during equal changes in speed".
- b. **"equal changes in speed during equal intervals of time".**
- c. "equal changes in acceleration during equal distance intervals".
- d. "equal changes in time during equal distance intervals".

What was the point of Galileo's published dialogues on motion? He wanted to

- a. contrast Aristotle's theories with his own.
- b. demonstrate how mathematics can allow insights into physical phenomena.
- c. define the important terms used to describe motion.
- d. His intent was to do all of the above.

How would Aristotle explain the observation that, when both are released from the same height at the same time, a nail beats a toothpick to the floor?

- a. The toothpick is less aerodynamic than the nail.
- b. Nails contain more of the element Earth than do toothpicks.
- c. All metal objects are affected by magnetism.
- d. Wooden objects do not have a "natural state of rest".

DYNAMICS (85 QUESTIONS):

Somebody tosses you a lead brick. You catch it and feel a huge force. The equal & opposite reaction to the force you feel is the force

- a. that got the brick moving toward you originally.
- b. of gravity pulling the brick toward the earth.
- c. the thrower felt when he originally threw it.
- d. you applied to the brick to stop and catch it.

Why do we say that a person in freefall is experiencing "apparent weightlessness" (as opposed to real weightlessness)?

- a. The person's weight is causing the freefall, but no sensation of weight is felt.
- b. There is no such thing as real weightlessness.
- c. Gravity's effect is canceled while you are moving.
- d. Prolonged freefall can prevent you from becoming "a parent".

You pull on a rope attached to a spring scale attached to a wagon. The reading on the scale would depend *least* on which of the following?

- a. mass of the wagon
- b. your mass.
- c. wagon's rate of acceleration
- d. friction force between wagon and ground

According to the current laws of physics, all interactions in nature can be explained as the actions of ? fundamental forces.

- a. 1
- b. 2
- c. 3
- d. 4

You are pushing continuously on a large crate. It refuses to budge. From this observation you can conclude that

- a. the crate weighs more than you.
- b. the crate has a greater inertia than you.
- c. your applied force is being canceled by its reaction force.
- d. your applied force does not exceed the friction acting on the crate.

During a rocket launch, which of the following would have no effect on the acceleration rate?

- a. Fuel is burned and exhausted through the main thruster.
- b. The rocket changes its direction of motion.
- c. The exhaust plume loses contact with the ground.
- d. As it moves to higher altitudes, the air becomes less dense.

What is the mass of a body that weighs (on Earth) 200 N?

- a. 2 kg
- b. 20 kg
- c. 200 kg
- d. 2000 kg

Which of the following is true inside an orbiting spacecraft?

- a. all bodies are weightless.
- b. there is no inertia.
- c. everything is frictionless.
- d. astronauts are stronger.

Which type of friction is caused by the interlocking of microscopic surface irregularities?

- a. sliding
- b. rolling
- c. viscous
- d. all of the above

Sir Isaac Newton published his theories of motion in a work titled

- a. *Philosophiae Naturalis Principia*.
- b. Two New Sciences.
- c. The Fallacies of Aristotle.
- d. An Original Cosmology.

Any mass for which $\Sigma F = 0$ is said to be

- a. at rest.
- b. gravitationally neutral.
- c. in equilibrium.
- d. in freefall.

One newton of force is equivalent to 1

- a. $\text{kg}\times\text{m}/\text{s}$
- b. $\text{kg}/\text{m}\times\text{s}^2$
- c. $\text{kg}\times\text{m}^2/\text{s}$
- d. $\text{kg}\times\text{m}/\text{s}^2$

The sum of two force vectors is greatest when they are

- a. perpendicular.
- b. equal and opposite.
- c. parallel and in the same direction.
- d. in the ratio of 2:1.

Which type of friction is a function of speed?

- a. rolling
- b. sliding
- c. viscous
- d. ubiquitous

Which of the following properties would have *no* effect on a body's rate of fall through air?

- a. shape
- b. size
- c. weight
- d. All of the above would have an effect.

Which of the following is *not* a vector quantity?

- a. force
- b. weight
- c. velocity
- d. mass

What is the acceleration of a 20 kg body to which a net force of 10 N is applied?

- a. 200 m/s^2
- b. 30 m/s^2
- c. 2 m/s^2
- d. 0.5 m/s^2

If a stalled car is being pushed by a force of 700 N and pulled by a force of 1000 N and friction with the road is 300 N, then the net force acting on it is

- a. 0 N
- b. 600 N
- c. 1400 N
- d. 2000 N

Under which conditions would your *apparent weight* in an elevator exceed your *true weight*?

- a. moving downward and speeding up
- b. moving downward and slowing
- c. moving upward at constant speed
- d. moving upward and slowing

A rope draped over a massless pulley has two 30 N weights attached to one end and a 60 N weight on the other. The pulley is suspended from a spring balance. What force does it register?

- a. zero
- b. 30 N
- c. 60 N
- d. 120 N

Friction force between the ground and you is 50 N, and the ground and a piano is 100 N. Thus

- a. the piano must weigh more than you do.
- b. you will be unable to move the piano.
- c. the bottom surface of the piano must be very rough.
- d. you cannot slide the piano horizontally with a continuous push.

Choose the best definition of *force*. A force is

- a. just another term for "inertia".
- b. something that causes acceleration.
- c. required to hold a body at rest.
- d. what keeps a moving body in motion.

Which of the following questions is concerned with *dynamics*?

- a. How high will a ball rise if thrown upward at 50 ft/s?
- b. Given "d" and "t", what is the average speed of a moving body?
- c. How long will it take a car going 45 mph to cover 150 miles?
- d. What amount of force is needed to overcome 20 N of friction?

You weigh 100 pounds and are standing with each foot on a separate bathroom scale. Which of the following must be true?

- a. The difference of the scale readings must be 100 pounds.
- b. The sum of the scale readings must be 100 pounds.
- c. Both scales will show a reading of 100 pounds.
- d. Both scales will show a reading of 50 pounds.

You are standing on a scale in an elevator. The elevator is moving downward at a constant speed of 10 m/s. Your weight reading on the scale will be ?_ if you were at rest.

- a. lower than
- b. the same as
- c. higher than
- d. One cannot tell without knowing the mass of the scale.

Which of the following is not a factor affecting the acceleration of a given body?

- a. mass of body
- b. magnitude of force
- c. direction of force
- d. type of force

Terminal velocity is a state of equilibrium characterized by

- a. air drag being equal to weight.
- b. inertia being overcome by gravity.
- c. weight being canceled by acceleration.
- d. freefall being balanced by weightlessness.

In what language was the Principia written and published?

- a. Greek
- b. Latin
- c. Italian
- d. English

Which of the following questions is concerned with *kinematics*?

- a. What acceleration does 20 N net force cause on a 5 kg mass?
- b. If $a = -4 \text{ m/s}^2$, and $v = 8 \text{ m/s}$, then what is "v" at $t = 2 \text{ s}$?
- c. If equilibrium exists, and $F = 9 \text{ N}$, then what is $-F$?
- d. What is the mass if 20 N of force causes 3 m/s^2 acceleration?

What is the weight of a 5 kg mass? (assume $g = 10 \text{ N/kg}$)

- a. 0.5 kg
- b. 5 kg
- c. 5 N
- d. 50 N

Forces are always, without exception, created in

- a. large vector groups.
- b. equal and opposite pairs.
- c. empty space, far from material bodies.
- d. gymnasiums and health clubs.

Aristotle believed that earthly objects would move uniformly if

- a. they were removed from their "natural place".
- b. a continuous "violent force" acted on them.
- c. only inertia could somehow be canceled.
- d. they contained at least 1 part "quintessence".

Newton believed that any body would move uniformly if

- a. the net force acting on it was zero.
- b. inertia was canceled by a large enough force.
- c. any amount of force acted on it.
- d. gravity could somehow be canceled.

If a body has a mass of 50 kg on Earth, then it will have a mass of ___ kg on the Moon.

- a. 0.5
- b. 5
- c. 50
- d. 500

If a body is at rest then you can conclude that

- a. there are no forces acting on it.
- b. the net force acting on it is zero.
- c. sooner or later it will begin to move.
- d. a lot of friction must be acting on it.

Newton's 2nd Law claims that acceleration depends on what?

- a. amount of force
- b. direction of force
- c. amount of mass
- d. All of the above affect acceleration.

Data: $m = 5000 \text{ g}$ and $V = 1000 \text{ cm}^3$. Conclusion: $\rho = __ \text{ g/cm}^3$

- a. 0.2
- b. 0.5
- c. 5
- d. 5,000,000

A horse is a horse, of course of course, but *weight* is a $__?$, regardless of source.

- a. density
- b. mass
- c. volume
- d. force

Adding the vector "5" to the vector "4" gives what result?

- a. 1
- b. 9
- c. 20
- d. One cannot tell without knowing the vectors' directions.

If a net force of 10 N causes a body to accelerate at 20 m/s/s, then its mass = $__?$ kg.

- a. 0.5
- b. 2
- c. 30
- d. 200

Which of the following is not a factor affecting a body's apparent weight?

- a. local g-field strength
- b. its mass
- c. rate of acceleration
- d. its speed

You "act" with a push of 40 N on a 5 kg mass, accelerating it at 4 m/s^2 . The mass will "react" and push back on you with a force of

- a. 20 N.
- b. 40 N.
- c. 60 N.
- d. 80 N.

If a 40 kg mass is observed to accelerate at 10 m/s^2 , then the net applied force must be

- a. 0.25 N.
- b. 4 N.
- c. 50 N.
- d. 400 N.

The referee walks up to you and punches you in the nose. The equal and opposite reaction to the force you feel is the force

- a. you subsequently apply to his nose.
- b. his feet applied to the ground when he threw the punch.
- c. your nose applies to his fist.
- d. he applied to his fist with his arm and body.

An ant harnessed to a large brick at rest on an air track can accelerate it! Your conclusion is:

- a. friction can be reduced to zero under certain conditions.
- b. a body's acceleration is directly proportional to its weight.
- c. the ant's pull exceeded whatever friction was present.
- d. equilibrium will occur when applied force equals net force.

Which of the following is true for falling bodies?

- a. The bigger the falling body, the faster it falls.
- b. Air drag decreases as the speed of fall increases.
- c. Terminal velocity is a function of a falling body's density.
- d. All falling bodies reach terminal velocity at the same speed.

The inertia of a body is

- a. proportional to its weight.
- b. equal and opposite to its mass.
- c. dependent on the strength of gravity.
- d. a variable scalar quantity.

In which of the following frames of reference would the Law of Inertia hold? The inside of a

- a. freely falling elevator.
- b. spaceship moving in a straight line with 1 g of acceleration.
- c. rapidly rotating Gravitron ride at the State Fair.
- d. train on a long banked curve.

Orbital motion can best be described as a state of motion wherein

- a. gravity is canceled by outward centrifugal forces.
- b. a circular trajectory is achieved with a net force of zero.
- c. frictional forces are canceled by the tangential component of "g".
- d. a very large horizontal speed permits continuous freefall. During circular

motion the centripetal force and instantaneous velocity are always

- a. equal.
- b. opposite.
- c. parallel.
- d. perpendicular.

Accelerating frames of reference are characterized by

- a. apparent weightlessness.
- b. the presence of g-forces.
- c. constant velocity.
- d. total lack of inertia.

The possibility of an artificial satellite in Earth orbit was first conceived of by

- a. Aristotle.
- b. Galileo.
- c. Newton.
- d. Whitehead.

Which of the following types of balances would not function correctly if used in a vertically accelerating elevator?

- a. inertial balance (oscillating horizontally)
- b. equal-arm balance
- c. spring balance
- d. None of the above would function correctly in this situation.

Centripetal acceleration is best described as a rate of change of

- a. tangential speed.
- b. radius.
- c. perpendicular.
- d. direction.

Which type of force would you not expect to observe in a constant-velocity frame of reference?

- a. centrifugal
- b. friction
- c. gravitational
- d. tension

During circular orbital motion, which of the following quantities is changing continuously?

- a. mass
- b. orbital radius
- c. circular speed
- d. instantaneous velocity

The horizontal and vertical velocities of a projectile are always

- a. parallel.
- b. equal.
- c. greater than zero.
- d. independent.

Which of the following is a constant throughout one cycle of an elliptical orbit?

- a. speed
- b. gravitational force vector
- c. orbital radius
- d. None of the above are constant in an elliptical orbit.

Astronauts in orbit experience "weightlessness" because

- a. they are in a constant-velocity frame of reference.
- b. the Moon's pull upward cancels the Earth's pull downward.
- c. they are in a vacuum and, thus, insulated from gravity.
- d. their ship, and everything in it, is falling.

Which of the following occurs on the way from apogee to perigee in an elliptical orbit?

- a. increasing speed and decreasing acceleration
- b. increasing speed and increasing acceleration
- c. decreasing speed and decreasing acceleration
- d. decreasing speed and increasing acceleration

Satellites are put into orbit above Earth's atmosphere because

- a. gravity will no longer affect them there.
- b. the moon's gravity can then help keep them aloft.
- c. frictional forces are thereby minimized.
- d. their inertia decreases to zero in a vacuum.

The centrifugal force on a revolving mass is 100 N. If the period is doubled the force will be

- a. 25 N.
- b. 50 N.
- c. 200 N.
- d. 400 N.

Which of the following will not affect a projectile's range?

- a. angle of launch
- b. projectile mass
- c. launch speed
- d. strength of gravity

If a pendulum has a period of 10 s, then what is its frequency?

- a. 10 Hz
- b. 3.14 Hz
- c. 0.314 Hz
- d. 0.1 Hz

If a revolving body has a circular speed of 10 m/s, then what is its period?

- a. 0.1 s
- b. 10 s
- c. 314 s
- d. One cannot tell from the given information.

The Foucault pendulum was the first proof that the Earth actually rotates. This was based on the observation of

- a. changes in the pendulum's inertia.
- b. a decrease of the pendulum's period.
- c. an apparent rotation of the pendulum's plane of swing.
- d. motion of the "fixed stars" relative to the pendulum.

Which of the following would be at its maximum value at the apogee of an elliptical orbit?

- a. orbital radius
- b. escape velocity
- c. weight
- d. speed

Which of the following is a true statement?

- a. G-forces only occur in constant-velocity frames of reference.
- b. Choice of a frame of reference should be made on the basis of simplicity.
- c. A body in an accelerated frame loses all its inertia.
- d. The Earth frame of reference is at rest with respect to the stars.

Frames of reference that move at constant velocity

- a. are uniformly accelerated.
- b. can be treated as though they were at rest.
- c. produce g-forces in the direction opposite their motion.
- d. must be vectorized before inverting their 4-space field tensor.

Centripetal acceleration is that type of acceleration caused by __?__ forces.

- a. centripetal
- b. gee
- c. friction
- d. tangential

Spaceflight from the Earth to the Moon was a fantasy long before it was actually done. What famous science fiction author wrote about this topic 100 years before it became reality?

- a. Jules Verne
- b. Isaac Asimov
- c. Robert Goddard
- d. Johannes Kepler

Which of the following is not a valid example of a frequency?

- a. 20 Hz
- b. 415 cycles per second
- c. 250 oscillations
- d. 33 rpm

Why do we not notice a centrifugal force due to the rotation of Earth?

- a. Gravity cancels that force exactly to zero.
- b. The Earth's spin is too slow to create a centrifugal force.
- c. It acts in the same direction as the force of gravity.
- d. It is much weaker than gravity and not directly perceptible.

The statement "All motion is relative." is equivalent to which of the following statements?

- a. Velocities must be measured with respect to a specified frame of reference.
- b. Two bodies can never be at rest with respect to each other.
- c. The universe as a whole must not be in motion.
- d. Frames of reference must rotate.

During projectile motion, the horizontal velocity is $_{?}$ and the vertical velocity is $_{?}$.

- a. perpendicular - parallel
- b. component - resultant
- c. constant - accelerated
- d. zero - infinite

Subject: a rocket trip to the Moon. Select the true statement.

- a. The rocket's thrusters must be operating continuously.
- b. Gravity from Earth is the only force acting on the rocket.
- c. They must aim at where the Moon will be 65 hours from launch.
- d. Astronauts inside are weightless from launch to landing. Galileo said

that a ball dropped from the mast of a moving ship would land

- a. directly below its release point.
- b. astern (ahead of) the mast.
- c. aft (behind) the mast.
- d. on the captain's head.

What is the period of the *second* hand of a 12-hour clock?

- a. 1 min
- b. 1/60 min.
- c. 60 min.
- d. 1/12 min.

What is the period of the *minute* hand of a 12-hour clock?

- a. 1 min
- b. 1/60 min.
- c. 60 min.
- d. 1/12 min.

During a flight to the Moon, at a location near the halfway mark, which of the following is an *incorrect* description of the relevant dynamics?

- a. Short bursts of the engine are required to keep the ship on course.
- b. The combined gravity of the Sun, Earth and Moon affect the trajectory.
- c. While the engines are off the ship is in a state of freefall.
- d. Net acceleration is continuously zero.

What is the period of the *hour* hand of a 12-hour clock?

- a. 12 hours.
- b. 1/60 min.
- c. 60 min.
- d. 1/12 hour.

Centrifugal and centripetal forces are always

- a. opposite.
- b. perpendicular.
- c. canceled.
- d. constant.

The genius of Galileo and Newton was not just their discoveries about motion, but also their

- a. careful record-keeping for future generations.
- b. assumption that these same laws applied everywhere in the universe.
- c. ability to express these laws in mathematical form.
- d. clever experimental devices.

A train is moving at 20 mph to the north. Inside a boxcar of that train is a dog, walking at a speed of 5 mph toward the rear of the boxcar. On the dog's back is a flea, crawling at a speed of 2 mph toward the dog's head. What is the velocity of the flea relative to the Earth?

- a. 13 mph north
- b. 17 mph north
- c. 23 mph south
- d. 27 mph south

A train is moving at 30 mph to the south. Inside a boxcar of that train is a dog, walking at a speed of 8 mph toward the front of the boxcar. On the dog's back is a flea, crawling at a speed of 1 mph toward the dog's tail. What is the velocity of the flea relative to the Earth?

- a. 13 mph north
- b. 17 mph north
- c. 23 mph south
- d. 37 mph south

If a spinning top has a period of 0.10 seconds, then its angular speed would be ? degrees/s.

- a. 100
- b. 360
- c. 1000
- d. 3600

GRAVITY (35 QUESTIONS):

Newton published his theory of gravity in a work titled

- a. General Relativity.
- b. Principia.
- c. Orbium Gravitus.
- d. Astronomia Nova.

Newton probably never would have published his theories about motion and gravity without the moral and financial support of

- a. Johannes Kepler.
- b. William Herschel.
- c. Rene Descartes.
- d. Edmund Halley.

The point between the Earth and Moon where their g-fields are *equal* and *opposite*

- a. depends on the phase of the Moon and varies accordingly.
- b. is known as the "barycenter" of that system.
- c. would be located nearer the Moon than the Earth.
- d. doesn't exist, since gravity never repels — it only attracts.

Which of the following was not an office held by Isaac Newton?

- a. Master of the Mint
- b. Professor of Mathematics
- c. Knight of the Court of Queen Anne
- d. Vice President of the Royal Society

Newton's "Principles of Scientific Reasoning" were

- a. strikingly different from those used today.
- b. in direct contradiction to those used by the early Greeks.
- c. guidelines for scientific deduction and induction.
- d. geometric reformulations of Kepler's three laws.

Which of the following configurations will produce the *largest* tides on Earth?

- a. Earth at perihelion + Moon at perigee
- b. Earth at perihelion + Moon at apogee
- c. Earth at aphelion + Moon at perigee
- d. Earth at aphelion + Moon at apogee

Newton's First Law (of inertia) applied to Kepler's Law of Elliptical Orbits implies that

- a. the sun must have much more mass than the Earth.
- b. gravity extends beyond the limits of Earth's atmosphere.
- c. there must be a force acting on the planets.
- d. the solar system probably formed from a large cloud of gas.

How did Newton test his hypothesis that Earth's gravity extended all the way to the Moon?

- a. He calculated the force acting between them.
- b. He compared the predicted and observed accelerations of the Moon.
- c. He measured directly the speed of the Moon in its orbit.
- d. He didn't. This was merely a "working hypothesis" used to establish mass ratios.

What two areas of knowledge did Newton's synthesis combine?

- a. planets and stars
- b. earth and sky
- c. time and space
- d. force and motion

Which of the following parameters, if changed, would *not* alter the gravitational field intensity at the surface of a planet?

- a. orbital radius
- b. total mass
- c. average density
- d. diameter

Kepler's laws of planetary motion were both

- a. kinematic and dynamic.
- b. empirical and theoretical.
- c. kinematic and empirical.
- d. empirical and dynamic.

Newton's Laws of Motion were both

- a. kinematic and theoretical.
- b. kinematic and empirical.
- c. dynamic and theoretical.
- d. dynamic and empirical.

Why did Newton suspect that the Sun was the source of the force on the planets?

- a. It was the most massive object anywhere in the whole system.
- b. He had calculated its gravity and the numbers just matched.
- c. It was located near the center of all the planets' orbits.
- d. Nothing else could produce the required amount of magnetism.

Which scientist suggested that space was filled with a thin and invisible fluid?

- a. Voltaire
- b. Descartes
- c. Herschel
- d. Einstein

Which of the following configurations will produce the *smallest* tides on Earth?

- a. Earth at perihelion + Moon at perigee
- b. Earth at perihelion + Moon at apogee
- c. Earth at aphelion + Moon at perigee
- d. Earth at aphelion + Moon at apogee

Why do we attach the honorific *Sir* to Isaac Newton's name?

- a. All recipients of the Nobel Prize receive this honorary title.
- b. The British use "Sir" just like we use "Mr."
- c. He was knighted by the Court of Queen Anne.
- d. It's just a term of endearment, as in "Sir Charles" (Barkley).

The revelation that occurred to Newton, when he observed the proverbial apple fall, was that

- a. all types of fruit were accelerated equally by gravity.
- b. gravity might also be causing the Moon to accelerate toward the Earth.
- c. apples must exert equal and opposite forces on the Earth.
- d. gravity from the Moon would also cause bodies to fall.

A satellite in geosynchronous orbit must be placed at an altitude where

- a. the gravitational pulls of the Earth and Moon cancel.
- b. the orbital period equals Earth's rotation period.
- c. its orbital plane contains the Earth's axis of rotation.
- d. gravity from the Earth has decreased to, essentially, zero.

Even though Jupiter has 318 times the mass of the Earth, its surface gravity is only 2.5 times greater than Earth's. This is a result of its

- a. greater distance from the Sun.
- b. being composed entirely of cold gases.
- c. extremely rapid rotation.
- d. **disproportionately greater size.**

Your weight on the surface of Earth is 640 N. Your weight at a distance of 3 Earth radii above the surface will be

- a. 80 N.
- b. **40 N.**
- c. 20 N.
- d. Zero. You would be "weightless" that far from the Earth.

Which of the following scientists was the first to apply the Newtonian theory of gravity to the motion of double stars?

- a. Stephen Hawking
- b. **William Herschel**
- c. Rene Descartes
- d. Edmund Halley

Which of the following factors did not contribute to the rapid growth of scientific knowledge in society during Newton's lifetime?

- a. the formation of scientific organizations
- b. improved craftsmanship and availability of instrumentation
- c. **establishment of the highly-motivating "Nobel prize"**
- d. development of new mathematical analysis methods

Why did Newton suspect that planets were subject to the same laws that governed the motions of objects on Earth?

- a. **Galileo's observations had shown them to be material objects.**
- b. Since they moved, they had to be subject to the laws of motion.
- c. Quintessence studied in the lab had behaved as normal matter.
- d. The forces acting on them produced constant accelerations.

The revelation that occurred to Newton, when he observed the proverbial apple fall, was that

- a. gravity accelerated fruit in proportion to its weight.
- b. apples fall towards the Earth, rather than away from it.
- c. **the Moon is also falling towards the Earth.**
- d. it would be cheaper to buy produce by weight on the Moon.

Your weight on the surface of Earth is 400 N. Your weight at a distance of 1 Earth radius above the surface would be

- a. 400 N.
- b. 200 N.
- c. **100 N.**
- d. Zero. You would be "weightless" above the Earth's atmosphere.

Your weight on Earth is 500 N. Your mass must be about

- a. 1400 kg.
- b. 500 kg.
- c. **50 kg.**
- d. 9.8 kg.

Which of the Laws of Scientific Reasoning justifies this logic? "The observed acceleration of the planets implies a force must be acting on them." (Careful, there are two close choices.)

- a. The simplest theory is the best theory.
- b. To equal effects assign equal causes.
- c. The properties of matter are universal.
- d. Science evolves.

Which scientist first measured the value of "G", the universal gravitational constant?

- a. Isaac Newton
- b. Edmund Halley
- c. William Herschel
- d. Henry Cavendish

Kepler's Law of Periods was explained by Newton's proof that T^2/R^3 was a function of

- a. temperature.
- b. the orbited body's mass.
- c. orbital speed.
- d. period and radius.

What political concept was modeled after Newton's laws of dynamics?

- a. executive privilege
- b. freedom of speech
- c. national sovereignty
- d. checks and balances

The best explanation for why tides occur is that the

- a. Earth's rotation is irregular, causing the seas to "slosh".
- b. Sun exerts greater forces on Earth than do the other stars.
- c. gravity from Earth's core doesn't spread out evenly.
- d. Moon pulls harder on some parts of the Earth than others.

Newton's calculation of the Sun/Earth mass ratio (333,000/1) was proof that

- a. the Sun pulled harder on the Earth than the Earth did on the Sun.
- b. Earth's density was less than the Sun's.
- c. Kepler's Law of Periods was only a coincidence.
- d. a geocentric universe was physically impossible.

What evidence led Newton to suspect that Earth's gravity weakened with distance?

- a. pendulum experiments done at the tops of mountains
- b. geologic data on density variations in the Earth's core
- c. the fact that Full Moons produce larger tides than Quarter Moons
- d. taller mountains were almost always located near the equator

How did Newton explain Kepler's Law of Periods? He simply

- a. showed mathematically that T^2/R^3 was a function of the mass of the Sun.
- b. combined his 3rd Law with Kepler's Law of Periods.
- c. reasoned that "matter has universal properties".
- d. deduced that R^3 was always a constant in orbital motion.

What is the significance of the very small magnitude (10^{-11}) of "G"?

- a. Gravity is a weak force, compared to the other forces of Nature.
- b. Measurements to establish the value of "G" are extremely difficult.
- c. Only very large masses will emit noticeable amount of gravity.
- d. All of the above are significant implications.

VECTORS-1 (27 QUESTIONS):

If a standard 2-dimensional coordinate system is used, then a vector resultant with both of its component totals negative is in quadrant

- a. I.
- b. II.
- c. III.
- d. W.

What is the magnitude of the resultant of the vectors 2 m/s @ 50° and 2 m/s @ 230° ?

- a. 0.5 m/s
- b. 1.8 m/s
- c. 3.1 m/s
- d. 4.2 m/s

What is the magnitude of the resultant of the vectors 30 mi/hr north and 40 mi/hr west?

- a. 35 mi/hr
- b. 50 mi/hr
- c. 70 mi/hr
- d. 1200 mi/hr

What is the magnitude of the resultant of the vectors 4 m up, 7 m down, and 2 m up?

- a. 1 m up
- b. 1 m down
- c. 5 m up
- d. 5 m down

What is the inverse tangent of 0.5?

- a. 0.0087°
- b. 2°
- c. 26.6°
- d. 50°

What is the direction of the resultant of the vectors 2000 N @ 90° and 3000 N @ 180° ?

- a. 33.7°
- b. 56.3°
- c. 123.7°
- d. 146.3°

What is the direction of the resultant of the vectors 5 m/s @ 0° and 8 m/s @ 90° ?

- a. 32°
- b. 40°
- c. 58°
- d. 72°

The standard 2-dimensional Cartesian coordinate system places

- a. the "+x" axis 90° clockwise from the "+y" axis.
- b. the "x" axis at a 45° angle with the "y" axis.
- c. no negative directions on either axis.
- d. the axes intersecting at a point anywhere in the first quadrant.

Which of the following is *not* a vector quantity?

- a. velocity
- b. force
- c. displacement
- d. time

Vectors that are separated by a $_\?_\$ angle will have the greatest possible sum.

- a. 0°
- b. 90°
- c. 180°
- d. 270°

What is the sine of 70° ?

- a. 0.12
- b. 0.34
- c. 0.70
- d. 0.94

What is the effect of multiplying a vector by "-1"?

- a. The vector becomes only one unit long.
- b. It reverses the direction of the vector by 180° .
- c. The vector rotates 90 degrees clockwise.
- d. The vector becomes an "imaginary" quantity.

Three vectors, "X", "Y", and "Z", will add to a resultant of zero if

- a. $X + Y = -Z$
- b. $Y + Z = -X$
- c. $Z + X = -Y$
- d. The resultant will be zero in all of these cases.

A wind of 50 mi/hr to the northwest has a western component equal to

- a. 35.4 mi/hr.
- b. 45.0 mi/hr.
- c. 50.0 mi/hr.
- d. 70.7 mi/hr.

If one jet is flying south at 400 m/s, and another is flying east at 200 m/s, then they are moving away from each other at

- a. 117 m/s.
- b. 256 m/s.
- c. 447 m/s.
- d. 600 m/s.

Neither of a vector's two components can ever be $_\?_\$ the vector itself.

- a. less than
- b. equal to
- c. greater than
- d. in the same direction as

What is the inverse tangent of 42?

- a. 0.024°
- b. 0.90°
- c. 42°
- d. 88.6°

What is the cosine of 12° ?

- a. 0.21
- b. 0.43
- c. 0.98
- d. 1.12

When using "head-to-tail" vector addition, the resultant is drawn from ? to ?.

- a. head of the first vector - tail of the last vector
- b. head of the last vector - tail of the first vector
- c. tail of the first vector - head of the last vector
- d. tail of the last vector - head of the first vector

If a vector's x-component is positive and y-component is negative, then it is in Quadrant

- a. I.
- b. II.
- c. III.
- d. IV.

The X and Y components of a vector are equal if and only if its angle = ? degrees.

- a. 0
- b. 30
- c. 45
- d. 90

Under what conditions would the force exerted by a ball bearing on a ramp be equal to the weight of the ball bearing?

- a. when the ramp is horizontal
- b. when the ramp is sloped at 45°
- c. never
- d. always

The vectors embodied in Newton's 3rd Law are

- a. at right angles.
- b. parallel and proportional
- c. equal and opposite.
- d. of zero magnitude.

If head-to-tail vector addition brings you back to the tail of the first vector, then the *sum* =

- a. 180° .
- b. -1.
- c. their difference.
- d. zero.

What is the inverse tangent of 2?

- a. 0.035°
- b. 0.2°
- c. 0.5°
- d. 63°

What is the direction of the resultant of the vectors 2 m/s @ 90° and 2 m/s @ 180° ?

- a. 2°
- b. 4°
- c. 135°
- d. 270°

What is the cosine of 45° ?

- a. 0.707
- b. 0.45
- c. 1/45
- d. 45

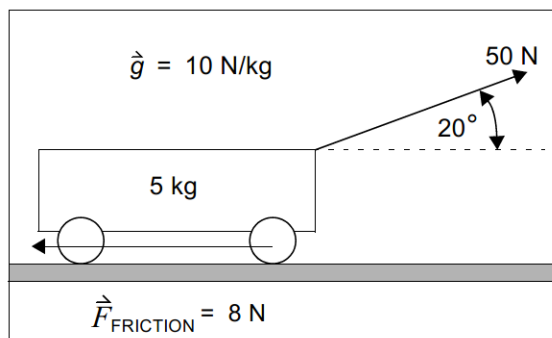
VECTORS-2 (20 QUESTIONS WITH GRAPHICS):

What is the net horizontal force on the cart?

- a. zero
- b. 10 N
- c. 39 N
- d. 47 N

What is the net vertical force on the cart?

- a. zero
- b. 33 N
- c. 50 N
- d. 67 N

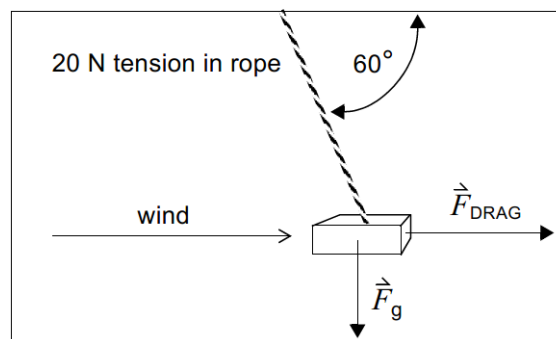


How much drag force is acting on the brick?

- a. 10 N
- b. 20 N
- c. 30 N
- d. 40 N

What is the weight of the brick?

- a. 7.3 N
- b. 17.3 N
- c. 27.3 N
- d. 40 N

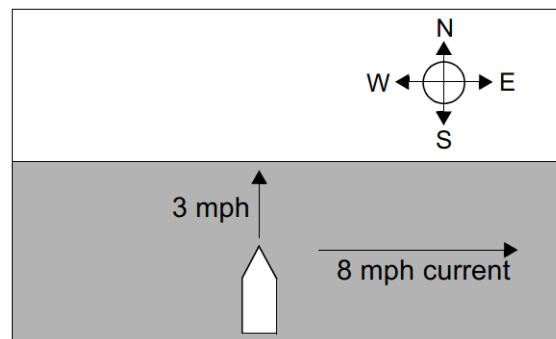


What is the boat's resultant velocity?

- a. 5 mph
- b. 7.4 mph
- c. 8.5 mph
- d. 11 mph

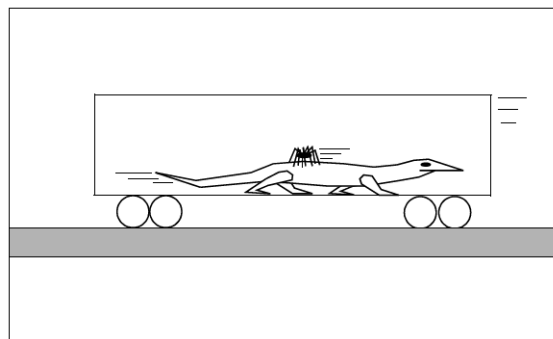
What is the boat's direction of motion?

- a. 12° east of north
- b. 31° east of north
- c. 45° east of north
- d. 69° east of north



A boxcar is rolling to the left at 20 mph. Inside is a lizard slinking to the right at a speed of 30 mph (relative to the boxcar). On the lizard's back is a spider who is crawling to the left at a speed of 4 mph (relative to the lizard). What is the speed of the spider relative to the ground?

- a. 6 mph
- b. 10 mph
- c. 14 mph
- d. 26 mph

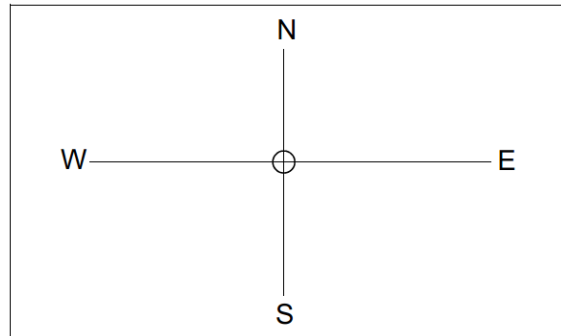


You walk 5 m E, 12 m N, 2 m S, and 8 m W. How far are you from your starting point?

- a. 8.3 m
- b. 10.4 m
- c. 15.2 m
- d. 17.9 m

What is the *total* distance traveled?

- a. 13 m
- b. 24 m
- c. 27 m
- d. 36 m

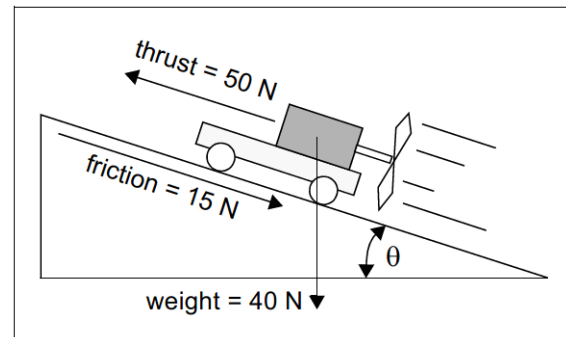


If $\theta = 0$, the net horizontal force on the cart =

- a. 5 N
- b. 15 N
- c. 35 N
- d. 65 N

What angle of ramp would be required for gravity to just hold the cart motionless?

- a. 43°
- b. 49°
- c. 58°
- d. 61°

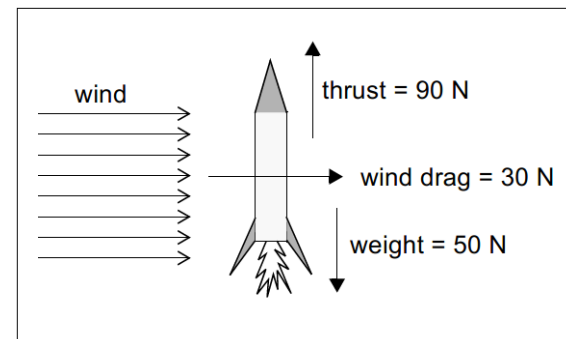


What is the net force acting on the rocket?

- a. 30 N
- b. 40 N
- c. 50 N
- d. 60 N

What is the rocket's direction of motion relative to horizontal?

- a. 37°
- b. 45°
- c. 53°
- d. 68°

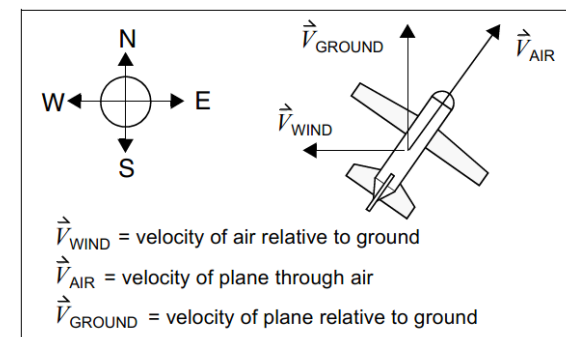


Wind speed = 40 mph. If the plane's air speed = 60 mph, then its speed relative to the ground =

- a. 45 mph
- b. 60 mph
- c. 80 mph
- d. 100 mph

To travel due south the plane would aim

- a. northeast.
- b. west.
- c. southeast
- d. north.

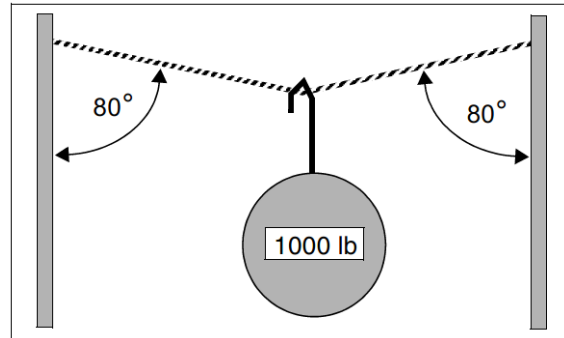


The vertical component of tension in either side of the rope equals

- a. one half the weight of the hanging mass.
- b. the horizontal component.
- c. twice the total tension.
- d. zero.

How much tension is in the rope?

- a. 500 lb
- b. 985 lb
- c. 1462 lb
- d. 2879 lb

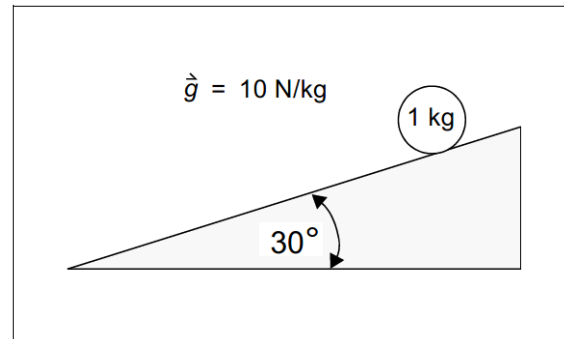


At what rate will the bearing accelerate?

- a. 1 m/s^2
- b. 5 m/s^2
- c. 8.7 m/s^2
- d. 10 m/s^2

The force from the bearing to the inclined plane equals the weight of the bearing

- a. only if friction is zero
- b. when the inclination angle is zero
- c. never
- d. always

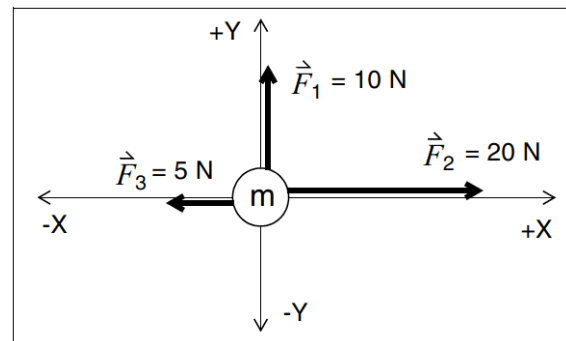


What is the magnitude of the resultant force?

- a. 12 N
- b. 18 N
- c. 23 N
- d. 26 N

What is the direction of the resultant force?

- a. 34°
- b. 42°
- c. 55°
- d. 70°

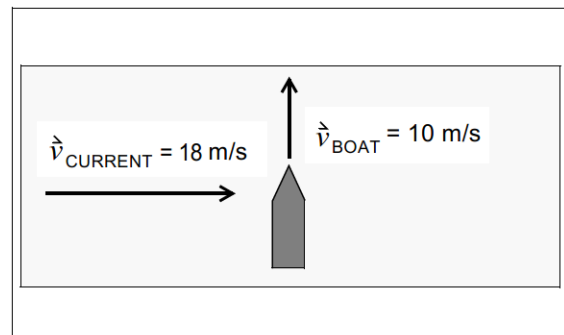


What is the resultant speed of the boat?

- a. 8 m/s
- b. 18 m/s
- c. 21 m/s
- d. 28 m/s

What is the boat's direction of motion with respect to the river bank?

- a. 0.55°
- b. 18°
- c. 29°
- d. 35°

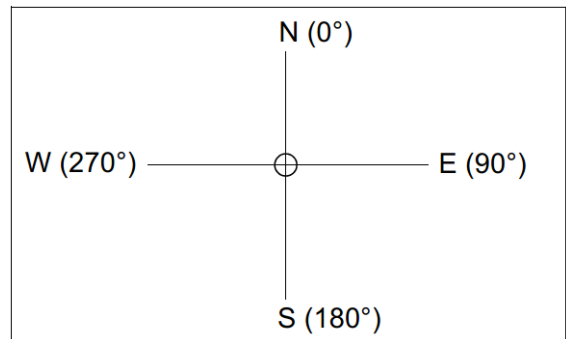


You walk 5 km N, 5 km E, 2 km S, and 3 km W.
What is your distance from your starting point?

- a. 3.6 km
- b. 4.2 km
- c. 5.3 km
- d. 15 km

What is the compass direction *back* to home?

- a. 56°
- b. 214°
- c. 236°
- d. You are home.

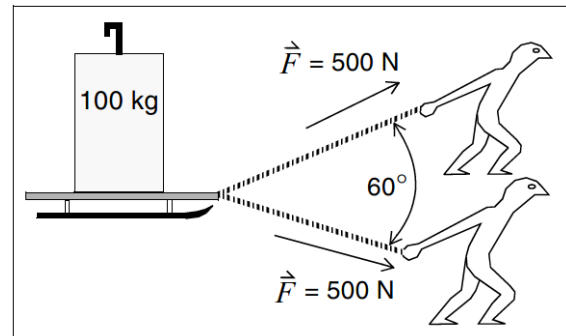


If the sled is being pulled at constant speed, then its sliding friction must equal

- a. 502 N
- b. 866 N
- c. 1000 N
- d. 2149 N

Decreasing the angle between the ropes would

- a. increase the tension.
- b. stall the sled.
- c. cause acceleration
- d. have no effect.

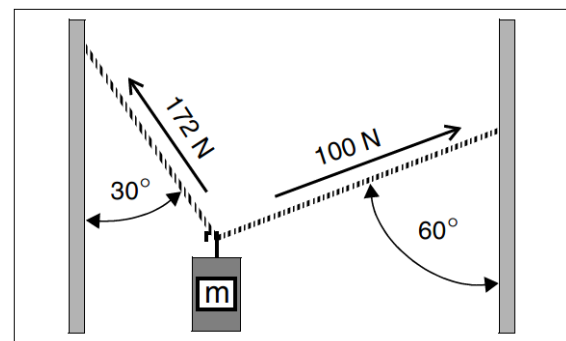


The weight of the suspended mass is

- a. 86 N
- b. 100 N
- c. 199 N
- d. 272 N

The horizontal force applied by the right rope should be ? the horizontal force of the left rope.

- a. less than
- b. equal to
- c. greater than
- d. twice

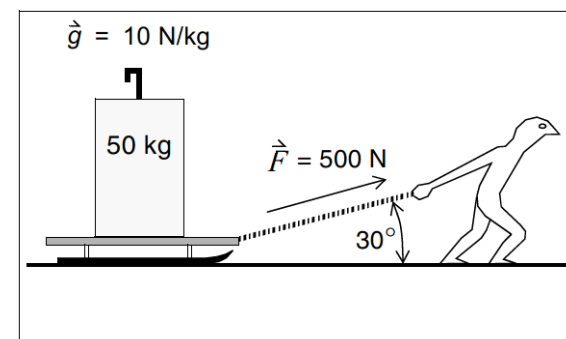


If the sled is being pulled at constant speed, then its sliding friction must equal

- a. 100 N.
- b. 433 N.
- c. 1000 N.
- d. 2149 N.

What is the weight of the 50 kg mass?

- a. 5 N
- b. 50 N
- c. 500 N
- d. 5,000 N

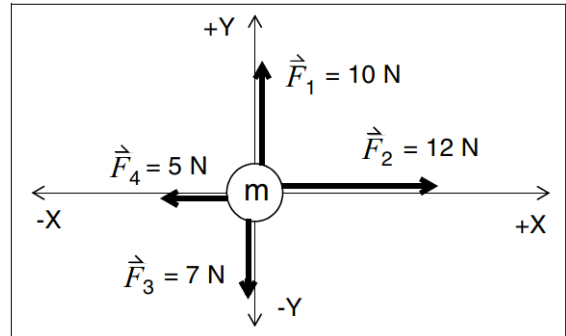


What is the magnitude of the resultant force?

- a. 7.6 N
- b. 18 N
- c. 23.2 N
- d. 34 N

What is the direction of the resultant force?

- a. 23°
- b. 42°
- c. 55°
- d. 70°

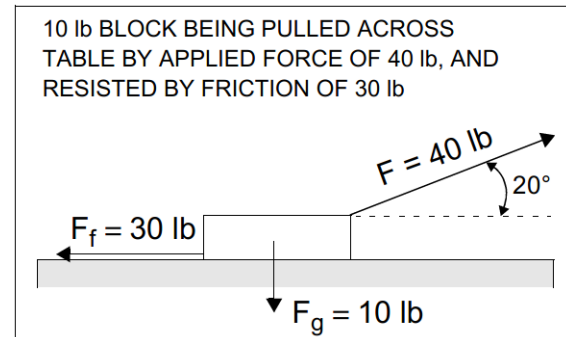


The vertical component of the pulling force is

- a. 40 lb.
- b. 13.7 lb.
- c. 3.7 lb.
- d. zero.

The net horizontal force on the block is

- a. zero
- b. 7.6 lb.
- c. 37.6 lb.
- d. 70 lb.

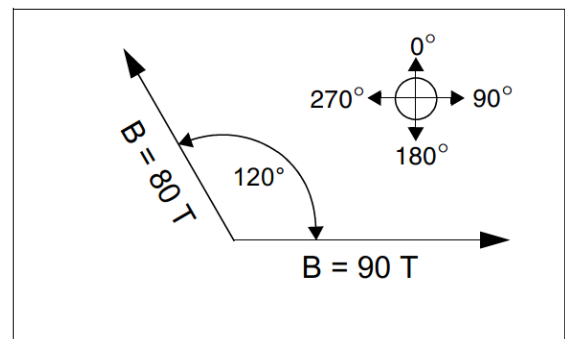


What is the total magnetic field strength?

- a. 45.8 T
- b. 60.0 T
- c. 85.4 T
- d. 96.1 T

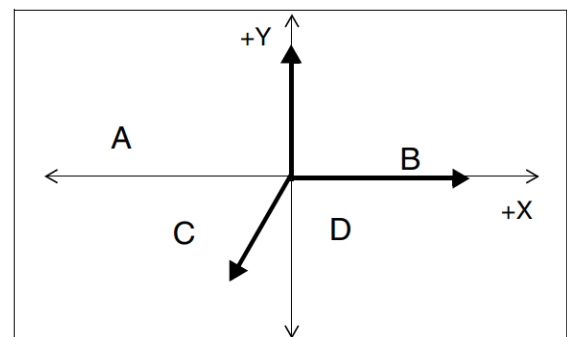
In which direction would your compass point?

- a. 32.5°
- b. 54.2°
- c. 66.8°
- d. 73.7°



Head-to-tail addition of the three vectors would create a resultant terminating at which point?

- a. A
- b. B
- c. C
- d. D



IMPULSE & MOMENTUM (37 QUESTIONS):

You dissolve 10 g of solute A into 50 g of solvent B in a sealed flask. Later, you notice a precipitate has formed. The remaining solution masses 40 g. Select the most valid hypothesis:

- a. 5 g of solute have combined with 5 g of solvent.
- b. 10 g of solvent B are now in the precipitate.
- c. 15 g of solute A have been absorbed by the solvent.
- d. 20 g of mass remains in the precipitate.

One proposed method of space propulsion is "solar sailing". Large sails deployed by a spacecraft would be pushed by the collisions of light particles (photons), much like a normal sail is pushed by the wind. Why would highly reflective mirror-like sails be the most effective?

- a. They would be the least likely color to overheat.
- b. Less friction is felt by smooth surfaces.
- c. Reflection causes more impulse than absorption.
- d. Particles could be focused onto the ship for more thrust.

Which of the following is a constant during a chemical reaction occurring in a closed system?

- a. density
- b. temperature
- c. color
- d. mass

What British scientist was an advocate of the *mechanistic* view of Nature? He is also known for his studies into the physical properties of air.

- a. Robert Boyle
- b. Isaac Newton
- c. Christian Huygens
- d. William Blake

An impulse of 10 N-s is applied for 5 seconds to a 20 kg purple cube that is already moving at a speed of 100 m/s on the Winter Solstice. By how much does its momentum change?

- a. 2 kg-m/s
- b. 10 kg-m/s
- c. 50 kg-m/s
- d. 200 kg-m/s

If a 5 kg body is moving at a speed of 3 m/s, then it has a momentum of ? kg-m/s.

- a. 2.5
- b. 3
- c. 8
- d. 15

If a mass "m" is at rest, and it is given an impulse of X N-s, then its final momentum will be =

- a. X kg-m/s.
- b. X/kg-m/s.
- c. m/X kg-m/s.
- d. 2X kg-m/s.

The law of conservation of kinetic energy was proposed by

- a. Isaac Newton.
- b. Christian Huygens.
- c. Rene Descartes.
- d. Gottfried Leibniz.

Antoine Lavoisier's brilliant career came to an end when

- a. he married a wealthy French aristocrat.
- b. war broke out between France and England.
- c. he retired after winning the Nobel Prize in chemistry.
- d. the French revolution sent him to the guillotine.

If you mix 50 cc of alcohol with 50 cc of water you get only 98 cc of mixture. This shows that __?__ is not conserved.

- a. mass
- b. energy
- c. alcohol
- d. volume

Two carts of equal mass and equal speed collide on an air track. Their final speeds must be

- a. one half the original.
- b. twice the original.
- c. equal.
- d. zero.

A person on ice skates catches a brick and begins to move backward at $v = 2$ m/s. Allowing the brick to bounce off him instead would

- a. move him forward at 1 m/s.
- b. move him backward at 2 m/s.
- c. move him backward at 4 m/s.
- d. have no effect at all.

Lavoisier's experiment with the rusting nail led him to deduce that its mass increase was caused by the acquisition of __?__ from the surrounding atmosphere.

- a. water
- b. carbon
- c. oxygen
- d. momentum

Which of the following quantities is not conserved in a perfectly elastic collision?

- a. momentum
- b. relative velocity
- c. kinetic energy
- d. All the above are conserved under the specified conditions.

A 20 kg body collides with a 10 kg body in a closed system. If the 20 kg body loses 5 kg-m/s of momentum, then the other must gain

- a. 5 kg-m/s.
- b. 10 kg-m/s.
- c. 20 kg-m/s.
- d. One cannot tell without knowing the velocities involved.

Object 1 reverses its motion after colliding with object 2, which is at rest. You can conclude that

- a. object 1 has less mass than object 2.
- b. object 1 has more mass than object 2.
- c. object 2 has more momentum than object 1.
- d. object 2 must be held at rest by an outside force.

At the turn of the 17th century, scientists' evolving view of nature was to perceive it as a

- a. chaotic mixture.
- b. world machine.
- c. unknowable mystery.
- d. completely solved puzzle.

The ability of a body to return to its original shape after undergoing distortion is known as

- a. momentum
- b. impulse
- c. elasticity
- d. vis viva

Momentum is best described as a measure of a body's

- a. tendency to resist deformation during collisions.
- b. elasticity to mass ratio.
- c. ability to resist frictional deceleration.
- d. ability to exert an impulse on impact.

How much impulse does it take to change an object's momentum by 4 kg-m/s in a time of 5s?

- a. 4 N-s
- b. 9 N-s
- c. 20 N-s
- d. One cannot tell without knowing the object's mass.

The law of conservation of mass was first experimentally investigated by

- a. Isaac Newton.
- b. Antoine Lavoisier.
- c. Christian Huygens.
- d. Gottfried Liebnez.

The idea that matter is conserved was developed by early Greek philosophers, but was first stated formally by the Roman poet

- a. Isaac Newton.
- b. Lucretius.
- c. Francis Bacon.
- d. Erastosthenes.

When a body of $e = 0.5$ collides with a body of $e = 0.3$, the overall elasticity of the collision =

- a. 0.15.
- b. 0.2.
- c. 0.8.
- d. 1.6.

The *elasticity* of a body (sometimes called *coefficient of restitution*) is a measure of its

- a. hardness.
- b. mass-energy conversion ratio.
- c. ability to resist permanent deformation.
- d. momentum to impulse ratio.

If a ball with elasticity 0.5 is dropped from a height of 4 m, then how high will it bounce?

- a. 1 m
- b. 2 m
- c. 4 m
- d. 8 m

How much impulse does it take to stop a 2 kg body moving at a speed of 4 m/s?

- a. 0.5 N-s
- b. 2 N-s
- c. 4 N-s
- d. 8 N-s

The law of conservation of mass does not hold true in reactions

- a. catalyzed by electricity.
- b. that give off gaseous products.
- c. involving radioactivity.
- d. where a solute becomes dissolved.

An inelastic collision run backwards in time is equivalent to

- a. an elastic collision.
- b. a gravitational collapse.
- c. an explosion.
- d. no motion at all.

In which of the following cases is momentum not conserved?

- a. non-linear collisions
- b. bodies interacting without physical contact
- c. outside impulses are acting
- d. objects stick without rebound

When a gun is fired, conservation of momentum requires it to

- a. recoil.
- b. heat up.
- c. weigh one bullet less.
- d. emit smoke.

If mass A strikes mass B elastically in a linear collision, and A and B have equal mass, then the

- a. first mass will come to a dead stop.
- b. first mass will continue on with half its original speed.
- c. struck mass will move away with twice the original speed.
- d. struck mass will not move at all.

An impulse of 40 N-s on a 120 kg object will change its velocity by

- a. 0.333 m/s.
- b. 3 m/s.
- c. 40 m/s.
- d. one cannot tell without knowing its original velocity.

If a body's original momentum is zero, then, by definition, its final momentum will be equal to

- a. twice its original momentum.
- b. the total change in speed.
- c. the total impulse applied to it.
- d. its elasticity divided by its mass.

If you are walking and come to a stop, and if momentum is a conserved quantity, then where has all your original momentum gone?

- a. Into the Earth, producing a negligible change in its motion.
- b. Into the air, since you were in contact with air particles.
- c. Nowhere. You still must have it in some form.
- d. It needn't have gone anywhere. The system is not closed.

Chemical reactions are best described as a(n)

- a. rearrangement of atoms of matter.
- b. conversion of mass into energy.
- c. transformation of inertia into heat.
- d. exchange of momentum between virtual particles.

If a ball dropped from 4 m rebounds to a height of 3 m, then its elasticity is

- a. 0.56.
- b. 0.75.
- c. 0.86.
- d. 1.25.

Two bodies collide. To predict their final velocities one does not need to know the

- a. elasticity.
- b. carts' masses.
- c. initial velocities.
- d. type of force involved.

WORK & ENERGY (36 QUESTIONS):

How much work is done on a 2 kg mass if its kinetic energy is increased from 200 J to 400 J in a time of 4 seconds?

- a. 25 N-m
- b. 50 N-m
- c. 100 N-m
- d. 200 N-m

Doubling the mass *and* speed of a body will increase its kinetic energy by what factor?

- a. 2
- b. 4
- c. 8
- d. 16

In which of the following cases is *work* being done on the body?

- a. Force is applied perpendicular to its motion.
- b. It is at rest and being held in place by gravity.
- c. Remaining in the same location, it spins with increasing RPM.
- d. It slides with constant speed along a frictionless surface.

When you compress a spring the elastic potential energy will

- a. increase.
- b. decrease.
- c. convert to heat.
- d. remain constant.

What is the kinetic energy of a 3 kg mass moving at 4 m/s?

- a. 24 J
- b. 36 J
- c. 48 J
- d. 144 J

The first *quantitative* measurement of heat as a form of energy was accomplished by

- a. Benjamin Thompson.
- b. Isaac Newton.
- c. Gottfried Wilhelm Leibniz.
- d. James Prescott Joule.

Complete the analogy: *work* is to *energy* as

- a. *force* is to *speed*.
- b. *time* is to *impulse*.
- c. *momentum* is to *mass*.
- d. *impulse* is to *momentum*.

We can speak of the human body as a *machine* because it

- a. gives off heat.
- b. transforms energy.
- c. uses its "fuel" with 100% efficiency.
- d. can store energy internally.

In terms of energy transformations the *opposite* machine to a photovoltaic (solar) cell is a

- a. light bulb.
- b. radio.
- c. compass.
- d. pulley.

In which of the following situations are you *not* doing work on a sled?

- a. pushing it at constant speed on a level frictionless surface
- b. pulling it at constant speed up an inclined plane
- c. pushing it with acceleration on a level surface
- d. lifting it vertically with a pulley system

Benjamin Thompson's observation of ? suggested to him that heat was a form of energy

- a. meteor fragments
- b. caloricons
- c. cannon boring
- d. steam spectra

Which of the following is *not* a simple machine?

- a. lever
- b. pulley
- c. chain
- d. inclined plane

When a pitched baseball is struck by a bat it must momentarily come to rest before rebounding. In what form is its energy at this point?

- a. elastic potential
- b. chemical potential
- c. rotational kinetic
- d. linear kinetic

An electric pulley can lift 2 kg to a height of 4 meters in a time of 5 seconds. Its power output =

- a. 8 W.
- b. 16 W.
- c. 40 W.
- d. 64 W.

By what amount can 200 J of work increase the potential energy of a 50 kg mass?

- a. 4 J
- b. 50 J
- c. 200 J
- d. 10000 J

An elevator uses 40 J of energy to lift a 2 kg mass to a height of 1 m. What is its efficiency?

- a. 5%
- b. 20%
- c. 50%
- d. 100%

One kW.hr (kilowatt-hour) is an amount of energy equal to

- a. 60 J.
- b. 3600 J
- c. 6000 J.
- d. 3,600,000 J.

The ? is an example of a "machine" that transforms elastic potential energy into kinetic.

- a. tether ball
- b. furnace
- c. catapult
- d. chin-up bar

To increase the energy of a body by 5000 joules using a force of 50 newtons, that force will have to be applied for

- a. 100 seconds.
- b. 250,000 seconds.
- c. 100 meters.
- d. 250,000 meters.

The ? is an example of a machine that transforms kinetic energy into potential energy.

- a. slingshot
- b. toaster
- c. vaulting pole
- d. chin-up bar

Heat energy is sometimes measured in units of

- a. momentum.
- b. calories.
- c. degrees.
- d. moles.

What is the metric prefix meaning *millions*?

- a. "k" (kilo)
- b. "m" (milli)
- c. "M" (mega)
- d. "G" (giga)

The *joule* (J) is equivalent to which of the following units?

- a. N/m
- b. kg-m/s
- c. N-m
- d. kg/N-s

In terms of energy transformations the *opposite* machine to a windmill is a(n)

- a. waterwheel.
- b. treadmill.
- c. electric fan.
- d. pendulum.

Potential energy is best defined as energy that is

- a. moving.
- b. dissipating.
- c. stored.
- d. negative.

Kinetic energy is best defined as energy of

- a. matter in motion.
- b. chemical reactions.
- c. heat.
- d. dormancy.

How fast does radiant energy move?

- a. 300 m/s
- b. 300,000 m/s
- c. 300,000,000 m/s
- d. 300,000,000,000 m/s

The idea that heat was a form of energy was first developed qualitatively by

- a. Benjamin Thompson.
- b. Isaac Newton.
- c. Gottfried Wilhelm Leibniz.
- d. James Prescott Joule.

What does the abbreviation "BTU" stand for?

- a. Boiling Temperature Universal
- b. British Thermal Unit
- c. Before Thermodynamic Utilities
- d. Benjamin Thompson Unit

The calorie is defined on the basis of

- a. expansion of mercury.
- b. rotation of Venus.
- c. rebound height of bolometers.
- d. temperature changes in water.

What is the efficiency of a machine that uses 50 J of energy to do 40 N-m of work?

- a. 40%
- b. 80%
- c. 90%
- d. 110%

Simple machines can multiply your input force, but do so at the expense of

- a. efficiency.
- b. power.
- c. distance.
- d. output force.

What category of energy would include *wind power*?

- a. elastic potential
- b. radiant
- c. heat
- d. linear kinetic

An electric hoist can lift a 2000 N weight to a height of 10 meters in a time of 5 seconds. Its power output =

- a. 0.5 kW.
- b. 4 kW.
- c. 80 kW.
- d. 640 W.

An elevator uses 40,000 J of energy to lift a 200 kg mass to a height of 10 m. Its efficiency =

- a. 5%
- b. 20%
- c. 50%
- d. 100%

Select the *false* statement. Energy is

- a. the ability to do work.
- b. a conserved quantity.
- c. measured in units of watts.
- d. manifested in many different forms.

KINETIC THEORY (52 QUESTIONS):

Your refrigerator has a total weight of 500 lbs and a base that measures 25" x 40". How much pressure does it exert on the floor?

- a. 0.5 psi
- b. 1 psi
- c. 2 psi
- d. 4 psi

The average pressure exerted by Earth's atmosphere is not =

- a. 1 atmosphere.
- b. 14.7 psi.
- c. 101,325 N/sq-meter.
- d. 25 mm Hg.

About how many gas particles could be fit into 1 m of length?

- a. thousands
- b. millions
- c. billions
- d. trillions

What keeps the particles in a gas in perpetual motion?

- a. heat being added continuously from outside
- b. perfectly elastic collisions
- c. their non-absolute zero temperature
- d. All of the above are valid reasons.

What holds up the column of mercury in a liquid barometer?

- a. the vacuum trapped at the top
- b. atmospheric pressure against the sides of the tube
- c. pressure from the liquid reservoir below
- d. natural friction within the system

Robert Frost's poem "West-Running Brook" is a commentary about what basic law of Nature?

- a. Second Law of Thermodynamics
- b. Newton's third law (action-reaction)
- c. Kepler's first law (elliptical orbits)
- d. Galileo's law of falling bodies

About how large are the particles in a gas?

- a. 10^{-9} m
- b. 10^{-10} m
- c. 10^{-11} m
- d. 10^{-12} m

Which of the following was not a component of Otto Stern's molecular speed experiment?

- a. vacuum chamber
- b. rotating drum
- c. special photographic paper
- d. high voltage grid

The ratio of the number of particles to the number of moles =

- a. Boltzmann's Constant.
- b. the Universal Gas Constant.
- c. Avogadro's Number.
- d. Maxwell's Index.

Why are living creatures not a counter-example to the law of entropy (that things always get less organized and "run down")?

- a. Living creatures eventually die and do get less organized.
- b. Outside energy is required to maintain the process of life.
- c. Whenever a living thing moves it causes air particles to mix.
- d. The laws of Nature do not apply to living creatures.

Otto Stern's molecular speed experiment confirmed that real gas particles followed whose theoretical speed distribution curve?

- a. James Clerk Maxwell's
- b. Jean Augustine Fresnel's
- c. Sir Isaac Newton's
- d. Otto Stern's

Which of the following scientists did not object to the kinetic theory on the basis that it contained paradoxes and inconsistencies?

- a. Friedrich Neitzsche
- b. Ernst Zermelo
- c. Josef Loschmidt
- d. Ernst Mach

At what temperature would the perpetual motion of particles in a gas (or any state of matter) come to complete stop?

- a. zero Fahrenheit
- b. zero Kelvin
- c. zero Celsius
- d. zero Torricelli

Which of the following factors affect a planet's ability to maintain a surrounding atmosphere?

- a. strength of gravity
- b. mass of gas particles
- c. average planetary temperature
- d. All of the above are valid factors.

The pressure inside a space station would be about 1 atm. How much outward force will be exerted on the 8 x 10 inch windows?

- a. 1200 lb
- b. 2000 lb
- c. 2400 lb
- d. 4000 lb

Which of the following is not a reason for the impossibility of perpetual motion machines?

- a. All energy transformations produce heat.
- b. Perfectly frictionless motion cannot be achieved.
- c. Heat flows naturally from high to low temperatures.
- d. All machines have less than 100% efficiency.

What happens to the absolute temperature of a gas if the speed of its particles is doubled? The absolute temperature would

- a. be cut in half.
- b. remain the same.
- c. also double.
- d. increase by a factor of four.

Which of the following gas molecules would have the greatest average speed at 500 K?

- a. hydrogen
- b. nitrogen
- c. carbon dioxide
- d. water vapor

What would happen to a gas if one could remove the *slowest* 50% of all the particles?

- a. P and T would both increase
- b. P and T would both decrease
- c. P would increase and T would decrease
- d. P would decrease and T would increase

Maxwell's Demon had the remarkable ability of being able to

- a. sort fast and slow gas particles.
- b. cause heat to flow from a cold region to a warm region.
- c. reverse the normal trend of entropy.
- d. That little demon could do all of the above.

The ruins of the Greek temple at Delphi are a good example of

- a. the inevitable increase of disorder.
- b. heat flow from higher to lower temperatures.
- c. how entropy decreases with time.
- d. Ionic architecture at its very finest.

Some biologists have suggested that the organic equivalent of Maxwell's Demon exists inside

- a. mitochondria.
- b. hemoglobin.
- c. neurons.
- d. enzymes.

Other quantities being held constant, a decrease in the volume of a sample of gas would cause an increase in the

- a. mean free path of its particles.
- b. entropy of the sample.
- c. pressure of the sample.
- d. mass of each particle.

Other quantities being held constant, an increase in the temperature of a gas will increase its

- a. pressure.
- b. volume.
- c. particle speed.
- d. all of the above would increase under those conditions.

If the volume of a gas is rapidly decreased, which of the following will not increase?

- a. temperature
- b. pressure
- c. density
- d. mean free path

Direct measurement of the speeds of particles in a gas was first accomplished by

- a. Otto Stern.
- b. James Clerk Maxwell.
- c. Sadi Carnot.
- d. Ludwig Boltzmann.

An air conditioner is needed to cool the air brought into a jet and delivered to the passenger compartment. Why is this so?

- a. The air at high altitudes is very hot (hot air rises).
- b. Its high relative speed has caused frictional heating.
- c. The air must first be compressed, a process which heats it.
- d. At high altitudes things are closer to the Sun and much hotter.

If fresh snow supports about 1 psi, and you weigh 100 pounds, then what area (total of both) snowshoes do you require?

- a. 14.7 square inches
- b. 50 square inches
- c. 100 square inches
- d. 200 square inches

Which of the following is not an assumption of the kinetic theory of gases?

- a. particle motion is random
- b. the particles are diatomic
- c. collisions between particles occur with perfect elasticity
- d. the particles involved are extremely small

Maxwell's Demon was a

- a. hypothetical entity that could cause decreases in entropy.
- b. calculating machine he used in his statistical analyses.
- c. hollow sphere that, when evacuated, could not be opened.
- d. scientific opponent named Ernst Zermelo, vociferous detractor of the kinetic theory.

If one removes the highest kinetic energy particles from a sample of gas, then the

- a. pressure will increase
- b. mean free path will decrease
- c. temperature will decrease
- d. density will increase

The second and third laws of thermodynamics are statistical, as opposed to theoretical. What does this statement tell us about these laws?

- a. Around 50% of the time their predictions are incorrect.
- b. They are applicable only to phenomena that can't be predicted.
- c. Violations of the laws are possible, albeit unlikely.
- d. They do not apply at all to "real world" situations.

Your shoes have a total sole area of 60 square inches. Your weight is 180 pounds. The pressure you exert on the ground is

- a. 3 psi.
- b. 6 psi.
- c. 12 psi.
- d. 5400 psi.

Which one of the following assumptions of the kinetic theory is least supported by the way things are in a "real" gas?

- a. The particles move randomly.
- b. Large numbers of particles are contained in typical samples.
- c. Particle collisions occur with perfect elasticity.
- d. The particles involved are extremely small.

What is meant by the phrase "heat death of the universe"?

- a. All matter in the universe will eventually catch fire.
- b. The total heat in the universe will gradually increase.
- c. The temperature of all matter will someday be uniform.
- d. Entropy will reduce the energy of the universe to zero.

What is "Brownian motion"?

- a. large scale statistical fluctuation in the energy of a gas.
- b. random motion of particles suspended in a gas or liquid.
- c. inevitable settling of particles to the bottom of a sample.
- d. a secret play used by girl scouts during flag football games.

If a sample of gas has a volume of 100 cc and a mass of 2 grams, then its density is

- a. 0.002 g/cc.
- b. 0.02 g/cc.
- c. 50 g/cc.
- d. 200 g/cc.

How much force is exerted on an area of 24 square inches by a gas at a pressure of 4 psi?

- a. 6 pounds
- b. 20 pounds
- c. 48 pounds
- d. 96 pounds

In the kinetic theory, heat is assumed to be

- a. a type of liquid.
- b. a form of caloric.
- c. made up of "heat particles."
- d. the kinetic energy of molecules or atoms.

The density of a certain gas is 0.05 g/cc. What is the mass of a 20 cc sample of that gas?

- a. 0.00001 g
- b. 1 g
- c. 5 g
- d. 400 g

In the kinetic theory, particles in a gas are assumed to exert forces on each other

- a. from any distance apart.
- b. only when they are in contact.
- c. almost continuously.
- d. never.

Why was the kinetic theory first applied to understand gases, as opposed to liquids or solids?

- a. The gaseous state of matter was the only one then known of.
- b. Matter in the other two states does not consist of particles.
- c. It is the simplest state to analyze.
- d. There was no particular reason for the choice.

Other quantities being held constant, a decrease in the density of a gas will cause a decrease in

- a. temperature.
- b. pressure.
- c. its particles' mean free paths.
- d. entropy.

Which of the following scientists invented the barometer?

- a. Evangelista Torricelli
- b. Robert Boyle
- c. Daniel Bernoulli
- d. Lord Kelvin

The entropy of an isolated system tends naturally over time to

- a. increase.
- b. decrease.
- c. remain constant.
- d. fluctuate randomly around a constant average value.

The ideal gas law applies most accurately to gases

- a. at very high temperatures.
- b. at very low pressures.
- c. that are poly-atomic.
- d. of all types under all conditions.

The *recurrence paradox* states that

- a. long-range history should be cyclic.
- b. most processes are irreversible.
- c. Newton's laws of motion are time-reversible.
- d. large-scale reversals of entropy are frequent and common.

The pressure a gas exerts on its container is due to the

- a. heat radiation generated during particle collisions.
- b. layer of gas particles bonded to the walls of the container.
- c. magnetic field created by the rapidly moving particles.
- d. collisions of gas particles with the inside container walls.

Why does heating a gas cause its volume to increase?

- a. The particles get bigger when their temperature goes up.
- b. Particles containing heat energy repel each other.
- c. The heat energy itself requires a certain amount of volume.
- d. Faster moving particles exert greater impact forces.

If a gas is slowly compressed at constant temperature (allowing heat to escape), pressure will increase due to the

- a. increased particle speed.
- b. increased number density.
- c. decreased mean free path.
- d. decreased average kinetic energy.

The *angstrom* (\AA) is a very small unit of

- a. distance.
- b. volume.
- c. time.
- d. speed.

Rapidly compressing a gas will cause a temperature increase. Select the *incorrect* reason:

- a. Friction between the particles produces heat.
- b. Work is being done by the compressing force.
- c. Particle speeds are being increased.
- d. Energy is being added to the system.

THERMODYNAMICS (61 QUESTIONS):

The most physically correct way to describe the operation of a refrigerator is to say that it

- a. "creates coldness".
- b. "moves heat".
- c. "destroys heat".
- d. "changes heat into cold".

Which of the following foods has the *lowest* energy content per gram?

- a. butter
- b. bread
- c. meat
- d. lettuce

About how many Calories are burned in a 1 hr walk?

- a. 20 C
- b. 200 C
- c. 2000 C
- d. 20,000 C

Until the mid 19th century, heat was believed to be

- a. an invisible fluid called "caloric".
- b. the kinetic energy of individual microscopic particles.
- c. a fourth state of matter.
- d. No theory of heat existed at this time.

Which of the following heat engines would have the *greatest* efficiency?

- a. heat source $T = 1000$ K, heat sink $T = 800$ K
- b. heat source $T = 500$ K, heat sink $T = 400$ K
- c. heat source $T = 200$ K, heat sink $T = 100$ K
- d. heat source $T = 100$ K, heat sink $T = 99$ K

Which of the following heat engines would have the *lowest* efficiency?

- a. heat source $T = 1000$ K, heat sink $T = 800$ K
- b. heat source $T = 500$ K, heat sink $T = 400$ K
- c. heat source $T = 200$ K, heat sink $T = 100$ K
- d. heat source $T = 100$ K, heat sink $T = 99$ K

The law of conservation of energy is also known as the 1st Law of Thermodynamics. This is a sensible interpretation since

- a. heat must be included to balance the energy budget.
- b. efficiencies less than 100% imply that heat has been produced.
- c. all energy transformations result in some heat production.
- d. All of the above are correct interpretations.

The 2nd Law of Thermodynamics states that machines must have efficiencies

- a. equal to zero.
- b. greater than their power factor.
- c. that increase with time.
- d. less than 100%.

Which of the following is a correct interpretation of the 3rd Law of Thermodynamics?

- a. Heat flows spontaneously from higher to lower temperatures.
- b. Heat is just another of the many forms of energy.
- c. Hotter objects contain more heat energy.
- d. All of the above are correct interpretations.

The thermodynamics of heat engines was first investigated by

- a. Rudolf Clausius.
- b. James Prescott Joule.
- c. Nicolas Sadi Carnot.
- d. Herman Von Helmholtz.

The units of "joules-per-kelvin" for entropy measurements imply that entropy can be thought of as a measure of

- a. a pure ratio, i.e., it is dimensionless.
- b. the temperature of the heat energy.
- c. absolute energy.
- d. inverse temperature.

Who first measured the conversion factor between heat energy and mechanical energy?

- a. Nicolas Sadi Carnot
- b. Friedrich Von Schelling
- c. Marquis De Caloric
- d. James Prescott Joule

What energy transformation occurs in *animal* cells?

- a. carbon dioxide + water + energy --> glucose + oxygen
- b. glucose + water + energy --> oxygen + carbon dioxide
- c. carbon dioxide + glucose --> water + oxygen + energy
- d. glucose + oxygen --> carbon dioxide + water + energy

What energy transformation occurs in *plant* cells?

- a. carbon dioxide + water + energy --> glucose + oxygen
- b. carbon dioxide + glucose + water --> energy + oxygen
- c. glucose + energy + water --> oxygen + carbon dioxide
- d. glucose + water --> energy + oxygen + carbon dioxide

The phrase "entropy spontaneously increases" means

- a. "the temperature of a closed system must remain constant".
- b. "the total energy of a system must increase".
- c. "heat energy seeks to lower its temperature".
- d. "theoretical efficiency is lower than actual efficiency".

Which of the following was not an advantage of James Watt's steam engine (over its precursors)?

- a. ability to use any combustible fuel
- b. versatility of application (rotary output)
- c. greater efficiency
- d. governor-regulated speed

Which substance is not a repository of energy available to the human body?

- a. blood sugar content
- b. fat cells
- c. bone marrow
- d. protein

What is the approximate efficiency with which human muscles use energy to do output work?

- a. 10%
- b. 20%
- c. 40%
- d. 80%

There is a painting titled *The Repast of the Lion*, by Henri Rousseau, showing a lion sleeping in the sunlight. Why is the "repast" really sunlight?

- a. Animals count on the Sun to warm their bodies during the day.
- b. The beam of light entering the lion's mouth is useless energy.
- c. The meal is (was) an herbivore, and plants "eat" sunlight.
- d. Eating involves consuming atoms that were formed inside stars.

James Watt was able to boost the efficiency of his steam engine tremendously by using

- a. governor for speed control.
- b. high pressure water inlet.
- c. separate container for condensation.
- d. plutonium heat source.

The process of using part of a machine's output to control its own input (as with James Watt's steam governor) is known as

- a. "optimization".
- b. "feedback".
- c. "insulation".
- d. "timing".

If 16 calories of heat change the temperature of a 4 gram block of substance X by 16 °C, then what is the specific heat of substance X?

- a. 0.125 cal/g-°C
- b. 0.25 cal/g-°C
- c. 0.5 cal/g-°C
- d. 2 cal/g-°C

Why does the specific heat of a gas depend greatly on sample conditions, whereas that of a solid or liquid is (mostly) constant?

- a. Gases do not have any properties that are constant.
- b. The number of particles in a gas depends on conditions.
- c. A gas consists of individual particles and is not continuous.
- d. The heat content of a gas, like its particle motion, is random.

Under what circumstances will heat flow from a low-T region to a high-T region?

- a. when energy is put into the system
- b. any time that $e > 1$
- c. always (this is the natural direction for spontaneous flow)
- d. never ever, no way, dream on, absolutely impossible!

Which scientist first formulated the 2nd Law of Thermodynamics using the concept of *entropy* as the central theme?

- a. Rudolf Clausius
- b. Herman Von Helmholtz
- c. James Prescott Joule
- d. Sadi Carnot

Heat flow from the source = 50 J; heat flow to the sink = 20 J. Work output = 10 J. This heat engine's *total* efficiency =

- a. 20%
- b. 40%
- c. 50%
- d. 60%

What area of science investigates how living creatures use food energy to do work?

- a. "bioenergetics"
- b. "mitochondostromy"
- c. "oxygluototics"
- d. "kinesoanatomy"

The first practical application of the steam engine as a power supply for locomotion over water was accomplished by

- a. Robert Fulton.
- b. James Watt.
- c. William Symington.
- d. Sadi Carrot.

Absolute zero temperature is approximately $_{-?}$ °C.

- a. 32
- b. 0
- c. -100
- d. -273

Which of the following statements about real heat engines is always false?

- a. Entropy will be increased by its operation.
- b. Higher temperature heat sources yield greater power output.
- c. Some heat will escape from the system without doing any work.
- d. The temperature of the heat sink will decrease over time.

Select the *false* completion: real heat engines

- a. increase the total entropy of the universe.
- b. derive their input heat by the combustion of some fuel.
- c. have an efficiency less than their theoretical maximum.
- d. never convert all of the heat flow into useful work.

The first operational heat engine, designed solely to pump water, was invented by

- a. Thomas Savery.
- b. Thomas Newcomen.
- c. James Watt.
- d. Sadi Carrot.

The *maximum* efficiency of any heat engine is dependent on the

- a. temperatures between which it operates.
- b. number of moving parts it contains.
- c. rate at which it does work.
- d. type of fuel supplying the heat.

Rudolf Clausius stated the thermodynamic law that, with the passage of time, the Universe's

- a. energy and entropy both remain constant.
- b. energy remains constant but its entropy increases.
- c. entropy remains constant but its energy decreases.
- d. entropy and energy both decrease.

The temperature of a body is directly proportional to the

- a. specific heat of the substance of which it is made.
- b. average kinetic energy of its constituent particles.
- c. heat energy required for a change of state.
- d. All of the above are correct statements.

If a heat engine is operating from a 600 kelvin source to a 200 kelvin sink, then what is its maximum thermodynamic efficiency?

- a. 3%
- b. 20%
- c. 33%
- d. 67%

In what century did the Industrial Revolution begin?

- a. 1600's
- b. 1700's
- c. 1800's
- d. 1900's

The original motivation in Joule's heat energy experiments was his desire to improve the efficiency of engines

- a. powering Her Majesty's fleet of warships.
- b. in the family brewery.
- c. that pumped water from the sea.
- d. in the first cargo aircraft.

The *steam turbine*, driven by heat from various fuels, generates the bulk of electricity in the world today. Who invented this high efficiency heat engine?

- a. Charles Parsons
- b. Matthew Boulton
- c. James Watt
- d. Charlotte Dundas

The Industrial Revolution of the 19th Century had several negative side effects. Which of the following was not one of these negative effects?

- a. class struggle between the workers and the professionals
- b. urban pollution
- c. depletion of resources
- d. decrease of human life span

The term *thermodynamics* implies, by its two root words, that this area of physics is concerned with the study of

- a. heat and force.
- b. temperature and motion.
- c. energy and entropy.
- d. thermometers and springs.

Which of the following would *not* be considered a heat engine?

- a. automobile engine
- b. toaster
- c. refrigerator
- d. jet turbine

Believing strongly in the 1st Law of Thermodynamics, Wolfgang Pauli postulated the existence of something not yet actually observed. What was his postulate?

- a. an undetected particle called the "neutrino"
- b. the other two laws of thermodynamics
- c. an invisible heat fluid called "caloric"
- d. the law of "conservation of heat"

Select the highest temperature.

- a. 100 °C
- b. 100 °F
- c. 100 K
- d. The given temperatures are equal.

When a moving object slides to a stop its kinetic energy has

- a. simply ceased to exist.
- b. become potential energy.
- c. been transformed mostly into heat.
- d. increased to a maximum.

Why can we refer to the human body as a *machine*?

- a. It transforms energy.
- b. It gives off heat.
- c. It is 100% efficient.
- d. It can store energy.

The heat source for heat engines cannot practically be made any hotter than about 800 K, since

- a. there are no fuels that burn this hot.
- b. this would cause heat to flow back to the source.
- c. exhaust temperature would exceed that of the heat sink.
- d. the materials used for building the engine would melt.

The advantage of the *internal* combustion engine over the *external* combustion engine is

- a. greater heat capture.
- b. better control of air/fuel mixture.
- c. safety.
- d. All of the above are advantages.

Which of the following statements about *reversible* heat engines is true?

- a. Their coefficient of performance can be greater than 1.0.
- b. Larger temperature differences produce higher efficiencies.
- c. They help heat to flow from higher to lower temperatures.
- d. They can manufacture either "heat" or "cold" on demand.

Which temperature scale must be employed when doing most thermodynamics calculations?

- a. Fahrenheit
- b. Rankine
- c. Celsius
- d. Kelvin

Heat flow from the source = 80 J; heat flow to the sink = 50 J. Work output = 20 J. This heat engine's *total* efficiency =

- a. 25%
- b. 40%
- c. 62.5%
- d. 87.5%

Operation of any real heat engine will result in an entropy change for the entire system that is

- a. always a positive quantity.
- b. always a negative quantity.
- c. positive or negative, depending on the direction of heat flow.
- d. zero, by definition.

In an *ideal* heat engine, if 100 J of heat is extracted from the source and 80 J is delivered to the sink the work output is

- a. 0.8 J.
- b. 1.25 J.
- c. 20 J.
- d. 8000 J.

Which of the following would have to be considered in any law regarding total energy flow?

- a. energy in all its various forms
- b. heat
- c. work
- d. All of the above would have to be considered.

Which of the following has the greatest specific heat?

- a. water
- b. wood
- c. copper
- d. concrete

How much heat will it take to increase the temperature of 20 g of water by 40 °C?

- a. 0.5 cal
- b. 2 cal
- c. 60 cal
- d. 800 cal

100 g of water at 40 °C are mixed with 50 g of water at 10 °C. The mixture's temperature =

- a. 15 °C
- b. 20 °C
- c. 25 °C
- d. 30 °C

What is the result of using absolute temperatures in the equation: $\Delta H = (m)(c)(\Delta T)$?

- a. One obtains the answer in "cal" rather than "J".
- b. The *total* heat content, not the *change* in heat, is calculated.
- c. Entropy effects are thereby neglected.
- d. The answer is the same regardless of the temperature units used.

What does the abbreviation "BTU" stand for?

- a. Burning, Treating, or Unbonding
- b. British Thermal Unit
- c. Best Temperature Use
- d. Before Theory Upgrade

Count Rumford's heat theory was based on his observations of

- a. heat generated while drilling cannon barrels.
- b. the fermentation and heating of malt yeasts.
- c. bouncing balls dropped from great heights.
- d. open flames caused by lightning strikes.

The *kilowatt-hour* is a unit of measurement for

- a. power.
- b. heat.
- c. energy.
- d. temperature.

WAVES (53 QUESTIONS):

Waves that meet out of phase can cancel only if their ? are equal and opposite.

- a. wavelengths
- b. densities
- c. amplitudes
- d. speeds

Transverse waves that lie in the same plane are said to be

- a. "longitudinal".
- b. "standing".
- c. "polarized".
- d. "aeronautical".

All points on a wave front must have equal

- a. phase.
- b. amplitude.
- c. direction of motion.
- d. All of the above are correct.

The maximum displacement of a wave's medium is referred to as its

- a. amplitude.
- b. speed.
- c. frequency.
- d. period.

Convex reflectors are capable of ? wave energy.

- a. scattering
- b. focusing
- c. interfering
- d. resonating

Water waves seem to come nearly straight in towards shore regardless of the wind direction.

This effect is caused by which wave phenomenon?

- a. refraction
- b. reflection
- c. diffraction
- d. interference

Select the example of a 1-dimensional oscillator closed (nodes) at both ends.

- a. guitar string
- b. airplane wings
- c. diving board
- d. flag pole

Select the example of a 1-dimensional oscillator open (antinodes) at both ends.

- a. suspension bridge
- b. skyscraper
- c. telephone line
- d. slinky in space

Select the example of a 1-dimensional oscillator open at one end and closed at the other.

- a. snowboard (a single ski)
- b. fencing foil (a sword)
- c. anchor chain (anchored)
- d. clothesline (standard)

You're listening to some music. A long sustained note is played. A picture frame rattles. Why?

- a. diffraction
- b. resonance
- c. refraction
- d. interference

Which type of wave distorts the medium by rotating it in a plane perpendicular to its ray?

- a. longitudinal
- b. transverse
- c. torsional
- d. compressional

Which type of wave distorts the medium perpendicular to the direction of propagation?

- a. longitudinal
- b. transverse
- c. torsional
- d. all of the above

Which type of wave distorts the medium parallel to the direction of propagation?

- a. longitudinal
- b. transverse
- c. torsional
- d. all of the above

If the frequency of a wave is 100 Hz and its wavelength is 50 m then its speed must be

- a. 0.01 m/s.
- b. 2 m/s.
- c. 5000 m/s.
- d. 100,000 m/s.

Who first measured the speed of sound to an accuracy comparable to modern values?

- a. William Derham
- b. Marin Mersenne
- c. Ernst Mach
- d. Christian Huygens

Standing waves have the remarkable characteristic of

- a. wavelengths that increase in direct proportion to frequency.
- b. fixed regions of constructive and destructive interference.
- c. not requiring a medium for propagation.
- d. being much taller than reclining waves.

The pitch of a sound is directly related to its

- a. amplitude.
- b. frequency.
- c. speed.
- d. polarization.

You see a flash of lightning. 15 seconds later you hear the rumble of thunder. How far away was the lightning?

- a. less than a mile
- b. about 3 miles
- c. about 5 miles
- d. about 30 miles

The speed of a wave is physically dependent on the

- a. energy contained in the wave.
- b. structure of the medium it moves through.
- c. rate of vibration of the wave source.
- d. All of the above affect the wave's speed.

How many times more intense is a 40 decibel sound compared to a 30 decibel sound?

- a. 1.67
- b. 2
- c. 10
- d. 100

A wave of length 4 m, frequency 8 Hz and speed 32 m/s enters a medium where its speed is reduced to 6 m/s. Its frequency in the new medium will be

- a. 2 Hz.
- b. 4 Hz.
- c. 8 Hz.
- d. 16 Hz.

If the speed of a wave is 4 m/s, and the frequency of the wave is 8 Hz, then the wave period =

- a. 0.125 s.
- b. 0.25 s.
- c. 0.5 s.
- d. 32 s.

If the frequency of a wave is 0.5 Hz, and its speed is 8 m/s, then its wavelength =

- a. 0.25 m.
- b. 0.5 m.
- c. 4 m.
- d. 16 m.

If a wave has a frequency of 2Hz, then

- a. 2 waves pass a given point in the medium every second.
- b. the source of the wave is vibrating 2 times each second.
- c. the medium goes through 2 cycles of distortion each second.
- d. All of the above are valid interpretations.

Two horns are louder than either sounding alone. This is an example of

- a. reflection.
- b. superposition.
- c. refraction.
- d. dissonance.

At what sound intensity level does damage to the human ear begin to occur?

- a. 80 db
- b. 130 db
- c. 180 db
- d. 230 db

What is the average speed of sound in air @ STP?

- a. 34 m/s
- b. 340 m/s
- c. 3400 m/s
- d. 34,000 m/s

The *sonic boom* effect is best described as a

- a. shock wave of superimposed sound waves.
- b. backfire caused by an accelerating aircraft.
- c. sound made as a plane passes through the sound barrier.
- d. conversion of sound energy into light.

Which of the following can change a wave's direction of motion?

- a. refraction
- b. reflection
- c. diffraction
- d. All of the above can effect such a change.

Interference patterns will arise whenever

- a. two wave sources operate in the same medium.
- b. a wave has a frequency that matches that of the medium.
- c. a wave source operates at a changing frequency.
- d. All the above are possible causes.

Parallel rays that strike a concave reflector will

- a. converge to a focal point.
- b. be immediately absorbed.
- c. refract and diverge.
- d. destructively interfere.

Which of the following is a correct statement of Huygen's Principle?

- a. For every wave there exists an exact inverse that could cancel it completely.
- b. All points on a wave are vibrations capable of generating more waves.
- c. No medium can conduct wave energy with 100% efficiency.
- d. Absolute polarization conducts resonance in decibel absorbing barriers.

The idea that any complex wave could be represented as a sum of many simpler waves was first theorized by

- a. Isaac Newton.
- b. Christian Huygens.
- c. Jean-Baptiste Fourier.
- d. Cynthia Sizer.

Which combination of factors would produce the *fastest* wave speed in a taut string?

- a. low string mass + low tension
- b. low string mass + high tension
- c. high string mass + low tension
- d. high string mass + high tension

All waves transfer ___ in the direction of their propagation.

- a. momentum
- b. mass
- c. energy
- d. slinky

Healthy humans can hear sound frequencies within what range?

- a. 100 - 20,000 Hz
- b. 20 - 25,000 Hz
- c. 20 - 20,000 Hz
- d. 100 - 25,000 Hz

The faintest sound audible to the average human ear is defined as

- a. 0 decibels.
- b. 0 W/cm^2 .
- c. 0 watts.
- d. 0 joules.

Which of the following wave types can propagate in solid media?

- a. transverse
- b. longitudinal
- c. torsional
- d. All of the above are correct.

When was the relationship between instrument string length and musical tone first discovered?

- a. in the 20th century
- b. sometime in the 1800's
- c. during the Renaissance
- d. over 2000 years ago

If a guitar string's fundamental frequency is 200 Hz, then the frequency of its 2nd harmonic =

- a. 100 Hz.
- b. 200 Hz.
- c. 400 Hz.
- d. 600 Hz.

Which of the following is equivalent to a frequency of 1000 kHz?

- a. 1 Hz
- b. 1 mHz
- c. 1 MHz
- d. 1 GHz

The acoustical engineering equivalent for a human body is a

- a. pile of towels.
- b. large wooden cylinder.
- c. full crate of oranges.
- d. felt-covered sand bag.

In which of the following mediums are sound waves propagated at the greatest speed?

- a. vacuum
- b. air
- c. water
- d. quartz

Sound propagates as a __?__ wave.

- a. longitudinal
- b. transverse
- c. torsional
- d. Any of the above could be correct, depending on the source.

Which of the following parameters does not change when a wave enters a new medium at an incident angle other than zero?

- a. speed
- b. wavelength
- c. frequency
- d. direction

What would increase the separation between antinodes in a two-source interference pattern?

- a. decrease the wavelength of the interfering waves
- b. increase the distance between the two sources
- c. decrease the distance of the observation point from the sources
- d. None of the above are correct.

Which of the following is not an example of a wave?

- a. ripples made by the wind blowing through a wheat field
- b. multiple-car front end to rear end collision
- c. fluttering of your car's antenna at certain speeds
- d. elbow-to-elbow jostling in a large, tightly-spaced crowd

Points on top of two successive wave crests are said to be

- a. "one cycle apart".
- b. "separated by one wavelength".
- c. "in phase".
- d. All of the above are correct interpretations.

What is it that gives various musical instruments their own unique and recognizable sounds?

- a. pitch
- b. amplitude
- c. harmonics
- d. loudness

Points where waves meet and destructively interfere are called

- a. "sources".
- b. "nodes".
- c. "polarons".
- d. "beats".

The science of sound waves and their interactions is called

- a. "wavonics".
- b. "phonics".
- c. "acoustics".
- d. "fidelatics".

When two source interference occurs in a 3-D medium the nodal and anti-nodal regions will be

- a. 1-dimensional (curves).
- b. 2-dimensional (surfaces).
- c. 3-dimensional (volumes).
- d. nonexistent.

The _?_ were the first to realize the mathematical relationship between the length of strings and the musical tones they produced.

- a. Japanese Samurai
- b. Pythagoreans
- c. Aborigines
- d. Druidic Warlocks

ELECTRICITY & MAGNETISM (119 QUESTIONS):

The difference in electrical potential energy between any two points is defined as a

- a. "voltage".
- b. "current".
- c. "power".
- d. "resistance".

On what factors does the voltage in a "Volta battery" depend?

- a. number of metal cell pairs stacked together
- b. types of metals used
- c. substance used for electrolyte
- d. All of the above are factors.

Who invented the first practical electric battery?

- a. Benjamin Franklin
- b. Alessandro Volta
- c. Hans Oersted
- d. Count Eveready

The basis of all electric batteries is the phenomenon of

- a. nuclear fusion.
- b. thermionic emission.
- c. electronegativity.
- d. positronic flow.

What is the intrinsic advantage of a *battery* compared to a *Leyden jar*?

- a. much higher voltages
- b. light weight and portability
- c. more continuous current
- d. greater power output

Electrical energy is really one of the many sub-categories of

- a. kinetic energy.
- b. potential energy.
- c. radiant energy.
- d. thermal energy.

If an electrical power source provides 6 C of charge with an energy of 12 J, then its voltage =

- a. 0.5 V.
- b. 2V.
- c. 18 V.
- d. 72 V.

An example of a common device that uses electric fields to accelerate free charges is the

- a. x-ray machine.
- b. filament of a light bulb.
- c. terminal(s) of a chemical battery.
- d. receiver of a telephone.

An electron falling through an electric field will increase its

- a. charge.
- b. resistance.
- c. kinetic energy.
- d. mass ratio.

When current flows through a conductor some of its energy is always lost to resistance. What happens to this "lost" energy? It

- a. shows up as charge leakage in a corona around the wire.
- b. is converted into heat which then dissipates.
- c. continues to flow until it is "recharged" at the battery.
- d. rebounds from the resistance and flows back to the source.

How much energy is gained by 2 C of charge as it falls through a potential difference of 8 V?

- a. 0.25 J
- b. 4 J
- c. 10 J
- d. 16 J

What is the purpose of a *resistor* in an electrical circuit?

- a. limiting current flow
- b. increasing voltage
- c. multiplying output power
- d. slowing the electrical force field

If you double the voltage in a circuit the current flow will

- a. also double.
- b. be cut in half.
- c. increase by a factor of four.
- d. remain the same.

If you double the resistance in an electric circuit the power output of the voltage source will

- a. also double.
- b. be cut in half.
- c. be reduced by a factor of four.
- d. remain the same.

Which of the following factors has no effect on the resistance of a given piece of wire?

- a. length
- b. diameter
- c. type of metal
- d. voltage applied

If you double the diameter of a conducting wire its resistance

- a. also doubles.
- b. will be cut in half.
- c. will be reduced by a factor of four.
- d. remains the same.

Who provided the first good evidence that there was a link between electricity and magnetism?

- a. Hans Oersted
- b. Benjamin Franklin
- c. Michael Faraday
- d. Charles Coulomb

An *electron volt* is equal to the amount of

- a. energy carried by a single charge in a 1 volt circuit.
- b. voltage needed to accelerate a single electron.
- c. energy released when an electron annihilates a positron.
- d. charge carried by a single coulomb in one amp.

A typical flashlight bulb operates from two 1.5 volts batteries (3 volts total) and draws 0.1 amp of current. The power used is __?__ watts.

- a. 0.033
- b. 0.3
- c. 0.9
- d. 30 W

Which of the following will not result in a magnetic force?

- a. charge at rest + magnet at rest
- b. charge at rest + magnet in motion
- c. charge in motion + magnet at rest
- d. charge in motion + magnet in motion in opposite direction

You are facing north. A wire running north and south carries a current towards you. How is the magnetic field oriented?

- a. north-south
- b. east-west
- c. clockwise
- d. counter-clockwise

What is the rule defining the orientation of field lines in a magnetic field? The field lines point

- a. from north to south.
- b. from south to north.
- c. from west to east.
- d. from east to west.

What is the shape of the magnetic field near a straight current-carrying wire?

- a. straight lines parallel to the wire
- b. straight lines at right angles to the wire
- c. radial lines pointing toward the wire
- d. concentric circles around the wire

Andre Ampere suspected that since a current-carrying wire exerted a force on a magnet, then two such wires should

- a. exert twice the force on a magnet.
- b. exert a force on each other.
- c. cancel the effect to zero.
- d. cause a stationary charge to accelerate.

Magnetic field strength is measured in units of *Tesla*. Which of the following is not an equivalent unit of measurement?

- a. newtons/amp-meter
- b. newton-seconds/coulomb-meter
- c. kilograms/coulomb-second
- d. amp-seconds/kilogram-ohm

A magnetic field is pointing toward the north. An electron is fired through it to the east. The force on the electron is

- a. upward.
- b. downward.
- c. to the left.
- d. to the right.

The north pole of a magnetic field is on the ceiling; its south pole is on the floor. A proton fired to the north will curve

- a. to the west.
- b. to the east.
- c. upward.
- d. downward.

What is the advantage of parallel circuits over series circuits?

- a. they need far less wire to make all the connections.
- b. continued and independent operation of the different branches.
- c. far less energy use and resulting low electrical bills.
- d. their lack of need for fusing or other overload protections.

Which of the following best describes the movement of electrons through a conductor?

- a. directed Brownian motion
- b. totally random velocity
- c. rapid oscillation about a fixed point
- d. smooth, continuous flow

The magnetic force law is a -dimensional vector expression.

- a. 1
- b. 2
- c. 3
- d. 4

The basic unit of magnetic field strength is the

- a. oersted.
- b. tesla.
- c. wimshurst.
- d. faraday.

How much current flows through a 500 W lamp powered by 100 V?

- a. 0.2 A
- b. 5 A
- c. 400 A
- d. 50,000 A

For his light bulb filaments, Edison wanted a substance with

- a. high resistance.
- b. low resistance.
- c. low melting point.
- d. zero conductivity.

The demonstrated reversibility of the opened the door to the "age of electrical power".

- a. battery
- b. arc lamp
- c. vacuum pump
- d. dynamo

What prevented the electric motor from becoming an immediate economic success?

- a. It was initially far too expensive for the average household.
- b. Operating one required extensive knowledge of electromagnetism.
- c. Few people had the electric power sources needed to run them.
- d. All of the above are valid reasons.

Which of the following was an incentive to the development of long-range distribution systems for electric energy, i.e., *power companies*?

- a. The energy sources were hot, noisy, and dirty.
- b. Demand for energy was increasing with industrialization.
- c. There was money to be made with energy as a delivered product.
- d. All of the above were incentives.

A wire running north-south is carrying current to the north. An electron fired north, over, and parallel to the wire will

- a. curve up.
- b. curve down.
- c. curve east.
- d. curve west.

Why does the magnetic force on a moving charged particle affect its direction of motion but not its speed of motion?

- a. The force only affects particles moving at constant speeds.
- b. It is not a true force and so cannot cause accelerations.
- c. The force acts at right angles and thus is centripetal.
- d. Moving charges have no inertia and must move at constant speed.

The first true electromagnetic motor was constructed by

- a. Hans Oersted.
- b. Michael Faraday.
- c. Joseph Henry.
- d. Charles Coulomb.

If a current exerts a force on a magnet, then a magnet should exert a force on a current. Why?

- a. principle of induced charge
- b. Newton's third law
- c. conservation of mass
- d. conservation of charge

Why do long distance electric power transmission lines use such high voltages, typically in the hundreds-of-thousands of volts?

- a. Less current is needed to deliver the same amount of energy.
- b. Electrons need high voltage to move over great distances.
- c. The large generators used normally produce those voltages.
- d. It keeps the birds (and people) off the transmission line towers.

Which of the following will induce a flow of charge through a conducting wire?

- a. moving the wire through a stationary magnetic field
- b. moving a magnetic past the stationary wire
- c. exposing the stationary wire to a changing magnetic field
- d. All of the above will induce a current.

What was the function of the "Faraday Disc Dynamo"?

- a. production of a constant electric current
- b. amplification of static charges
- c. induction of radial magnetic fields
- d. repulsion of steel-hulled vessels in the Spanish Armada

What is the function of an electric generator's *commutator*?

- a. prevention of voltage surges
- b. production of constant-direction current
- c. protection of overloads by fusing
- d. speed-limiting governor

What is the ultimate source of the energy produced by a generator?

- a. mechanical energy input to its rotating shaft
- b. mass-energy release from electrons and positrons
- c. magnetic fields canceling electric fields
- d. potential energy of compressed charges

The first electric lamp used commercially was invented by

- a. Hans Oersted.
- b. Michael Faraday.
- c. Humphrey Davy.
- d. Joseph Henry.

About what year did Thomas Edison begin to install the first electric lights in private homes?

- a. 1860
- b. 1880
- c. 1900
- d. 1920

Which of the following substances were not tried by Edison as filaments in his electric lights?

- a. fishline
- b. maple shavings
- c. the hair of a redheaded Scotchman's beard
- d. All of the above were tried.

What substance did Edison finally settle on for use as a filament in his electric lights?

- a. cork
- b. carbon
- c. tungsten
- d. the hair from a redheaded Scotchman's beard

Why did power companies finally settle on AC electricity for power transmission over DC?

- a. It was easily transformed between different voltages.
- b. It cost far less to produce.
- c. Special metals were no longer needed for the power lines.
- d. All of the above are valid reasons.

What does the "AC" in AC electricity stand for?

- a. accelerated charges
- b. alternating current
- c. absolute coulombs
- d. activated copper

What is the function of the device known as a *transformer*?

- a. conversion of AC electricity to DC
- b. recharging of electrical batteries
- c. increasing or decreasing voltages
- d. fighting off evil robots and criminals

What is a typical efficiency for electrical power transmission?

- a. 30%
- b. 50%
- c. 70%
- d. 90%

What event led to wide-spread fear and distrust of electrical energy during its early days?

- a. an explosion at Edison's first power plant
- b. a natural fear of lightning and other electric phenomena
- c. New York's adoption of electrocution for capital punishment
- d. Edison's own death while installing wiring in his home

Why will a transformer not operate properly using DC current?

- a. No induction will occur without the changing magnetic field.
- b. DC electrons carry only momentum and not energy.
- c. Only AC electricity can move through a coiled wire.
- d. It will operate, but at a slightly reduced efficiency.

What voltages are typically used for long-distance electrical energy transmission lines?

- a. 1000 V
- b. 10,000 V
- c. 100,000 V
- d. 1,000,000 V

The *kilowatt-hour* is a unit of measurement for

- a. power.
- b. resistance.
- c. efficiency.
- d. energy.

The function of a photovoltaic (solar) cell is to convert

- a. electrical energy into heat.
- b. magnetic energy into light.
- c. light into electrical energy.
- d. chemical energy into magnetic energy.

What is a typical efficiency for a photovoltaic (solar) cell?

- a. 25%
- b. 50%
- c. 75%
- d. 95%

If the primary circuit of a transformer uses 4 amps at 120 V and its secondary produces 240 V, then the secondary's current will be

- a. 2 amps.
- b. 4 amps.
- c. 8 amps.
- d. 16 amps.

Which of the following is not an example of a semiconductor?

- a. silicon
- b. plutonium
- c. selenium
- d. germanium

If the primary circuit of a transformer carries 120 V and has 20 coils, then the secondary with 80 coils will carry

- a. 30 V.
- b. 60 V.
- c. 120 V.
- d. 480 V.

What did Hertz use in his experiments as a detector of electromagnetic waves?

- a. loop of wire
- b. two parallel plates
- c. x-ray microscope
- d. long insulated glass rod

Electromagnetic waves in the frequency range of $4-7 \times 10^{14}$ Hz are also known as

- a. radio waves.
- b. x-rays.
- c. visible light.
- d. gamma rays.

Advocates of the *ether* felt that the speed of a beam of light should depend strongly on the

- a. relative motion between earth and "ether".
- b. local density of "ether".
- c. intensity of Earth's gravitational field.
- d. purity of the vacuum in the space surrounding Earth.

The first scientist to speculate that light may be an "electromagnetic wave" was

- a. Michael Faraday.
- b. Hans Oersted.
- c. James Maxwell.
- d. Joseph Henry.

Faraday's "lines of force" concept was first mathematically modeled by the Scottish physicist

- a. Joseph Henry.
- b. Hans Oersted.
- c. James Maxwell.
- d. Charles Wheatstone.

Which of the following historical figures was not a contemporary of James Maxwell?

- a. Sigmund Freud
- b. Richard Wagner
- c. Leo Tolstoy
- d. Immanuel Kant

The first experimental confirmation of Maxwell's electromagnetic theory was achieved by

- a. Heinrich Hertz
- b. Michael Faraday
- c. Albert Einstein
- d. Albert Michelson

Electromagnetic waves just shorter than those detectable by the human eye are known as

- a. ultraviolet light.
- b. gamma rays.
- c. infrared radiation.
- d. x-rays.

The Edison Electric Light Company's (almost) complete monopoly was first challenged by what fledgling corporation?

- a. General Electric
- b. Westinghouse
- c. Niagara Power and Light
- d. Arizona Public Service

Wave theory predicts that the wave medium's stiffness and density should affect a wave's

- a. amplitude.
- b. energy.
- c. speed.
- d. frequency.

The "great synthesis" achieved by Newton was that of Earth and Sky. Maxwell's corresponding synthesis was between

- a. Electricity and Magnetism
- b. Electromagnetism and Optics
- c. Gravity and Electromagnetism
- d. Time and Space

Maxwell's theoretically computed value for the propagation speed of electromagnetic waves was very close to the known speed of

- a. sound.
- b. light.
- c. ether.
- d. gravity.

The symmetry of Maxwell's electromagnetic model suggested that if a changing magnetic field produced an electric field, then a

- a. static magnetic field should produce nothing.
- b. changing electric field should produce a magnetic field.
- c. constant field of either type should spontaneously change.
- d. changing E + B field should produce a gravitational field.

Physicists are convinced that electric and magnetic fields are real things (not just mathematical abstractions) since they

- a. can carry and deliver energy.
- b. move at a finite speed as required by special relativity.
- c. are capable of independent existence apart from their source.
- d. All of the above are evidence that fields are real.

When an electromagnetic wave propagates through empty space its component electric and magnetic fields are linked by

- a. the ether.
- b. induction.
- c. gravity.
- d. duct tape.

Which series of waves is arranged by increasing wavelength?

- a. infrared, visible light, x-rays, gamma rays
- b. ultraviolet, visible light, microwaves, radio waves
- c. infrared, gamma rays, x-rays, ultraviolet
- d. gamma rays, x-rays, visible light, ultraviolet

The set of all possible electromagnetic radiation wavelengths is referred to as the

- a. "ionosphere".
- b. "schemata inducta".
- c. "electromagnetic spectrum".
- d. "charge-magnet continuum".

What does the radio abbreviation "AM" stand for?

- a. Amplitude Modulation
- b. Acronym Modernization
- c. Active Multiplexing
- d. Anti-matter Modules

Theoretical arguments by _?_ showed that the "ether" was really an unnecessary hypothesis.

- a. Albert Einstein
- b. Edward Morley
- c. James Clerk Maxwell
- d. Heinrich Hertz

Which equation describes the electrical levitation of a body against the force of gravity?

- a. $Q \times E = mg$
- b. $Q/E = F/m$
- c. $Q \times E = F/m$
- d. $Q/E = mg$

Who was the inventor of the lightning rod?

- a. Otto von Guericke
- b. Benjamin Franklin
- c. Joseph Priestley
- d. Charles Coulomb

Which scientist built the first machine capable of accumulating large electrical charges?

- a. Otto Von Guericke
- b. Alessandro Volta
- c. Charles Coulomb
- d. William Gilbert

The _?_ is a device capable of storing physically separated electric charges.

- a. capacitor
- b. battery
- c. torsion balance
- d. amberite

One body charged to +5 C is brought into contact with another charged to -3 C. After they are separated, each will have a charge of

- a. -15 C.
- b. -1.6 C.
- c. +1 C.
- d. +2 C.

The idea of "forces affecting distant objects without contact" has been replaced by that of

- a. "rays".
- b. "fields".
- c. "spacetime distortions".
- d. "ether waves".

Which scientist first successfully demonstrated the wireless transmission of communication signals across the Atlantic?

- a. Benjamin Franklin
- b. Guglielmo Marconi
- c. Heinrich Hertz
- d. Albert Michelson

Common radio and television "static" is usually caused by high frequency electromagnetic oscillations occurring in

- a. the metallic core of the Earth.
- b. automobile ignition and appliance sparks.
- c. solar flares from the Sun's atmosphere and other radiation from space.
- d. the fur of cats walking around the local neighborhood.

Which measurement device owes its invention to the existence of *lodestone*?

- a. barometer
- b. voltmeter
- c. compass
- d. sundial

What were the "charged bodies" used by Millikan in his famous electron charge experiment?

- a. polystyrene spheres
- b. oil droplets
- c. fragments of cat fur
- d. balloons

What experimental observation caused Oersted to suspect that the Earth was a magnet?

- a. levitation of horizontal electromagnets
- b. probing spherical lodestones with a compass
- c. observation of electrical currents in sedimentary rocks
- d. repulsion and attraction between cats and lightning bolts

One body charged to -6 C is brought into contact with another charged to -6 C . After they are separated, each will have a charge of

- a. -12 C .
- b. -6 C .
- c. zero.
- d. $+36\text{ C}$.

Electrical conductors exposed to an outside electrical field will experience a redistribution of charges known as

- a. "induction".
- b. "voltraction".
- c. "ionization".
- d. "grounding".

Two charged conducting bodies attract with a force of 5 N . They are 20 m apart. If they are brought into contact and then moved back to 20 m separation, they will now

- a. attract more strongly.
- b. repel.
- c. experience zero net force.
- d. What they will do cannot be determined from the given information.

Who first provided experimental verification of the inverse square law of electrical forces?

- a. Isaac Newton
- b. Benjamin Franklin
- c. Charles Coulomb
- d. Joseph Priestly

Which of the following is a similarity between electric and magnetic forces? Both forces

- a. can repel or attract.
- b. are active only when the source has been recently rubbed.
- c. seem to act between all objects.
- d. act via radial fields.

Benjamin Franklin thought that a body became charged due to

- a. creation of charged particles.
- b. transfer of an electric fluid.
- c. separation of previously neutral particles.
- d. fusion of ether and palladium.

Any two different substances become at least slightly charged by simple mutual contact. This

- a. is due to differing electron affinities.
- b. proves there are many different kinds of charge.
- c. is a result of chemical reactions on their surfaces.
- d. is only true for metals.

The smallest possible amount of freely existing charge is the

- a. electron.
- b. elementary charge.
- c. quark.
- d. coulomb.

About how much charge does a typical lightning stroke deliver?

- a. 0.1-1 C
- b. 1-10 C
- c. 10-100 C
- d. 100-1000 C

Which of the following statements about (electrostatic) induction is false? Induction

- a. can cause either attraction or repulsion.
- b. can result in electrical forces on a neutral body.
- c. occurs in metals more easily than in non-metals.
- d. results from charge redistribution within a body.

Two charged spheres exert a force on each other. If the charge on each sphere is cut by $1/2$, then the force between them will

- a. remain the same.
- b. reduce by $1/2$.
- c. reduce by $1/4$.
- d. reduce by $1/8$.

The unit of measurement for electrical currents is the

- a. coulomb.
- b. ampere.
- c. volt.
- d. farad.

Body 1 (charged with 4 C) contacts neutral body 2. It breaks contact with 2 and then contacts neutral body 3. The result is

- a. equal charge on all three bodies.
- b. 4 C on body 3.
- c. 2 C on body 3.
- d. 1 C on body 3.

Which two naturally occurring substances aroused early man's curiosity about electric and magnetic forces?

- a. amber and lodestone
- b. amber and quartz
- c. quartz and lodestone
- d. quartz and copper

Two charged bodies repel with a force of 8 newtons. If the charge on each is doubled, they will repel with a force of ___ newtons.

- a. 16
- b. 32
- c. 64
- d. 128

Two charged bodies attract with 16 newtons force. The distance between them is halved. They will now attract with a force of ? newtons.

- a. 8
- b. 16
- c. 32
- d. 64

Priestly's clue that the electric force might be an inverse square force (like gravity) came from the observation that

- a. charged bodies lost their charge over time.
- b. there were only two known types of charge.
- c. these forces could also act over great distances.
- d. the net force inside a hollow conductor was zero.

Modern developments in the study of electricity and magnetism were due to the release of the book *De Magnete*, by

- a. Benjamin Franklin.
- b. William Gilbert.
- c. Hans Oersted.
- d. Michael Faraday.

A current of 1 ampere is equivalent to what amount of charge transfer?

- a. 1 coulomb / volt
- b. 1 second / elementary charge
- c. 1 coulomb / second
- d. 1 joule / coulomb

Which of the following is a true statement about fields? Fields

- a. originate from a source.
- b. define a region of influence for an interaction.
- c. can be vector or scalar in their behavior.
- d. All of the above are true statements about fields.

Which of the following could be mapped as a scalar field?

- a. air temperature
- b. electric force
- c. wind velocity
- d. ocean currents

Which of the following could be mapped as a vector field?

- a. ground temperature
- b. water salinity
- c. gravitational force
- d. air density

What force will be felt by a charge of +2 C that is placed in an electric field of -4 N/C?

- a. 2 N attraction
- b. 2 N repulsion
- c. 8 N attraction
- d. 8 N repulsion

What effect is responsible for the attraction between a charged body and a neutral body?

- a. electrostatic induction
- b. gravitation
- c. electrostatic magnetism
- d. precipitation

If a charged body feels an attraction force of 20 N when placed in an electric field of +5 N/C, then what is the charge on that body?

- a. +4 C
- b. -4 C
- c. +100 C
- d. -100 C

3. Which of the following is a common property of electric and gravitational fields? They both

- a. either attract or repel.
- b. can be shielded by certain substances.
- c. are inverse square with distance.
- d. are traceable to a source.

Two charged bodies repel with a force of 12 newtons. They are 4 meters apart. If they are brought into contact they will

- a. repel more strongly.
- b. attract.
- c. experience zero net force.
- d. what they will do cannot be determined from the given information.

LIGHT & OPTICS (48 QUESTIONS):

Which of the following colors has the shortest wavelength?

- a. blue
- b. red
- c. green
- d. yellow

Which of the following is most difficult to explain using the particle model of light?

- a. reflection
- b. refraction
- c. scattering
- d. interference

Why is the sky blue?

- a. Blue light is preferentially scattered by air particles.
- b. The natural pigment in nitrogen is colored blue.
- c. All other colors are absorbed in the ionosphere.
- d. The Sun emits more blue light than any other color.

One *light year* is defined as the

- a. time it takes light to travel a distance of one year.
- b. distance traveled by a beam of light in a time of one year.
- c. time taken by light traveling a distance of one light year.
- d. distance it takes light to average a speed of one year/second.

The formation of colors by refraction of white light through a prism is known as

- a. "selective diffraction".
- b. "dispersion".
- c. "pigmentation".
- d. "polarization".

The *camera obscura* forms an image of an object by

- a. constructive interference of that object's shadow.
- b. allowing rays from the object to pass through a tiny pinhole.
- c. divergence of rays passing through its lens.
- d. polarizing the non-aligned rays on their way to the film.

What happens when one tries to obtain a single "ray" of light by passing a beam of light through increasingly narrow slits?

- a. One succeeds.
- b. The attempt will eventually be thwarted by diffraction.
- c. When the slit becomes smaller than a photon absorption occurs.
- d. Reflection from the edges will cause destructive interference.

Bees, ants, and a few other animals are able to navigate using natural sunlight that has become

- a. refracted.
- b. attenuated.
- c. Doppler-shifted.
- d. polarized.

The big debate about the nature of light could be expressed as

- a. "positive vs. negative".
- b. "energy vs. entropy".
- c. "wave vs. particle".
- d. "field vs. effect".

The apparent bending of a straw or spoon where it enters a container of water is due to light

- a. refraction.
- b. reflection.
- c. diffraction.
- d. interference.

Which two wave phenomena are responsible for the formation of that remarkable entity known as "Poisson's Spot"?

- a. reflection + diffraction
- b. diffraction + interference
- c. interference + resonance
- d. resonance + reflection

Newton's answer to the question "Why do objects appear to have different colors?" was: All natural bodies

- a. reflect one color of light more strongly than others."
- b. resonate at frequencies corresponding to particular colors."
- c. emit a glow due to random thermal motion of their particles."
- d. are made of atoms which have their own natural colors."

What did Newton prove by passing one of the colors of light he obtained from a prism through a second identical prism?

- a. Dispersion is a reversible phenomenon.
- b. The prism does not add colors to those originally present.
- c. Black light can be obtained by double refraction.
- d. Light travels at a finite (but very rapid) speed.

When smog forms over the city the sky becomes less blue and more gray. This is due to the fact that smog particles are

- a. themselves gray in color.
- b. larger than the average (clean) air particle.
- c. capable of refracting normally vertical light waves.
- d. able to emit light due to their large chemical bond energies.

Which of the following is *not* true of lasers?

- a. Their (light producing) atoms are vibrating in unison.
- b. Light emitted is of one pure color, or wavelength.
- c. Rays emerge perfectly parallel, exhibiting zero divergence.
- d. The light waves produced are constructively interfering.

When a beam of light goes from air into glass which of the following parameters will not be necessarily changed?

- a. wavelength
- b. speed
- c. color
- d. direction of propagation

The *idea* that "light is a wave" is an example of a "scientific

- a. model".
- b. analogy".
- c. hypothesis".
- d. theory".

The term *camera obscura* is a Latin phrase meaning

- a. "lost film".
- b. "astounding copier".
- c. "dark chamber".
- d. "unknown mechanism".

All forms of light are ultimately produced by

- a. vibrating electrical charges
- b. nuclear decay.
- c. exploding atoms.
- d. dimensional shifting.

What is the preferred symbol to represent "the speed of light"?

- a. L
- b. v
- c. c
- d. S

Which of the following is most difficult to explain using the *wave* model of light?

- a. reflection
- b. refraction
- c. scattering
- d. propagation in a vacuum

The first scientist to postulate a wave nature of light was

- a. Leonardo da Vinci.
- b. Christian Huygens.
- c. Thomas Young.
- d. Albert Einstein.

What shape of mirror is able to focus parallel rays of light to a single point?

- a. planar
- b. convex
- c. parabolic
- d. dihedral

Who invented the polarizing filter?

- a. Edwin H. Land
- b. Isaac Newton
- c. Robert Hooke
- d. Augustin Jean Fresnel

Red light has a wavelength of approximately $__ \text{Å}$.

- a. 2000
- b. 4000
- c. 6000
- d. 8000

When a beam of light enters a diamond its speed will

- a. increase.
- b. decrease.
- c. remain constant.
- d. become zero (it will be absorbed).

The incident, reflected, and refracted rays of light must all

- a. propagate through the same medium.
- b. lie in the same plane.
- c. be the same color.
- d. contain equal amounts of energy.

Who conducted the experiment that disproved Newton's particle model of light (by measuring light's speed through water)?

- a. Young & Huygens
- b. Romer & Blodgett
- c. Foucault & Fizeau
- d. Rogers & Hammerstein

How did Newton prove that "green light" was not itself composed of still other colors of light?

- a. Passing green light through a prism produced no further colors.
- b. Shining it on a red vase produced a distinctly "black" spot.
- c. Trapping it between two mirrors did not change its wavelength.
- d. Its frequency was directly measured to be a single harmonic.

You are looking northward at a lake. The light that reflects from its surface to your eyes is polarized in what direction?

- a. an east-west vertical plane
- b. a north-south vertical plane
- c. a horizontal plane
- d. a plane containing you, the lake, and the Sun

About how high up do you need to go before the sky loses its blue appearance, becomes black, and allows stars to be seen?

- a. 1 mile (1600 m)
- b. 5 miles (8000 m)
- c. 10 miles (16,000 m)
- d. 100 miles (160,000 m)

What event led Newton to investigate colored light?

- a. the appearance of a comet in the morning sky
- b. color distortions in telescope images
- c. a double rainbow on the day of his wedding
- d. fireflies in his beer

The "action at a distance" paradox was finally resolved by the introduction of a then-theoretical entity known as a

- a. "field."
- b. "photon."
- c. "node."
- d. "creedushram."

James Clerk Maxwell's theoretical calculation for the speed of electromagnetic waves came out very close to "c". Conclusion?

- a. Some types of fields can actually move through space.
- b. The value of "c" changes for different types of waves.
- c. Electricity is magnetically induced by light waves.
- d. Light is an electromagnetic wave.

Inside a *laser* light is produced by

- atoms vibrating in unison with photons.
- divergence of destructive rays.
- collimated refraction.
- incandescent protons.

What wave phenomenon places a limit on the fineness of details one can see with a telescope?

- reflection
- refraction
- diffraction
- interference

The rare optical properties of diamonds are a direct result of their

- extreme hardness.
- trace impurities of rare earths.
- large refractive index.
- slight natural radioactivity.

The phenomenon of *double refraction*, observed in some mineral crystals such as Iceland Spar, is due to which wave property?

- wavelength
- amplitude
- frequency
- polarization

What was the *ether*?

- a hypothetical medium for the transmission of light waves
- just another name for light particles, e.g., "photons"
- the opposite of inertia and the cause of resonance
- a substance with the properties of antimatter.

Who first demonstrated interference of light, a most convincing proof for the wave model?

- Isaac Newton
- Christian Huygens
- Thomas Young
- Olaus Romer

To photograph yourself in a mirror 4 feet away, you should set the camera focus distance to

- 2 feet.
- 4 feet.
- 8 feet.
- 12 feet.

The phenomenon known as *Poisson's Spot* was

- experimental evidence for the wave model of light.
- a dark ring formed around images in early telescopes.
- responsible for color-blindness epidemics during the 1800's.
- something Poisson's dog did on one of Galileo's carpets.

If you illuminate blue pigment with red light, the light that reflects back to your eyes will be

- red.
- blue.
- purple.
- nonexistent.

Isaac Newton published his theory of light in a work titled

- a. *Colour Luminose.*
- b. *Phenomena Piginentia.*
- c. *Opticks.*
- d. *Principia.*

What color sky would you expect on a planet whose atmosphere consists primarily of particles with diameter = 7000 Å?

- a. violet
- b. yellow
- c. red
- d. white

Yellow light has a wavelength of approximately $__?$ Å.

- a. 4000
- b. 5000
- c. 6000
- d. 7000

If a beam of light enters a material with a refractive index of 4.0, its speed will change to

- a. 4c.
- b. 2c.
- c. 0.5c.
- d. 0.25c.

Which of the following is not a necessary condition for the perception of light by humans?

- a. It must have a wavelength between 3900 and 7600 Å.
- b. A ray of the light must enter the eye and strike the retina.
- c. Waves in the beam must be vertically polarized.
- d. Its intensity must exceed some minimum threshold value.