

Section 1

- 1) For a car to accelerate, it must (a) have a constant speed (b) have a change in velocity (c) start from rest (d) none of the preceding
- 2) A force (a) always produces motion (b) is a scalar quantity (c) is capable of producing a change in motion (d) both (a) and (c)
- 3) The inertia of a body may be expressed in terms of its (a) speed (b) acceleration (c) mass (d) all of the preceding
- 4) Unless acted upon by an unbalanced force, an object will (a) remain at rest (b) remain in motion with a constant velocity (c) either (a) or (b) depending on initial conditions (d) change its inertia.
- 5) When Newton's second law is used to express weight, the accelerations is then (a) zero (b) due to gravity (c) directly proportional to the mass (d) none of the preceding
- 6) The air resistance on a falling object depends on its (a) shape (b) size (c) speed (d) all of the preceding
- 7) The action and reaction of Newton's third law (a) are in the same direction (b) have different magnitudes (c) act on different bodies (d) can be the same force
- 8) Suppose your physics book is lying on a table. How many forces are acting on it? (Neglect air pressure and extraterrestrial forces) (a) One (b) Two (c) Three (d) Four
- 9) All objects in free fall near the Earth's surface have the same (a) Velocity (b) Speed (c) Acceleration (d) Weight
- 10) When a car moves at constant speed on a straight road (a) There are no forces acting on it (b) There is a constant net force acting on it (c) There is no net force acting on it (d) The net force is downward
- 11) For two objects of different mass in free fall (a) The accelerations are different (b) The acting forces are different (c) Air resistance is a consideration (d) The more massive object will reach the ground first if released simultaneously
- 12) Which of the followings are the fundamental properties used to describe motion: (a) Length and weight (b) Length and time (c) Weight and height (d) Weight and speed
- 13) Any quantity capable of producing a change in motion is called a (a) Strength (b) Power (c) Force (d) Momentum

- 14) If the new force acting on an object is doubled, the acceleration is (a) None (b) Double (c) Triple (d) Quadruple
- 15) Kinetic friction is generally _____ static friction. (a) Less than (b) More than (c) Better than (d) equal to
- 16) The action and reaction forces of Newton's third law always (a) Act on different bodies (b) Are equal in magnitude (c) Are opposite directions (d) Are all of the above
- 17) Galileo's legendary Leaning Tower of Pisa experiment (a) Showed objects of different weights fall at different rates (b) Confirmed Aristotle's views on motion (c) Was actually done in Venice (d) Is seriously questioned with regard to authenticity
- 18) An automobile is traveling due east on an interstate highway at a constant velocity of 65 miles per hour. The **unbalanced** force acting on the car with respect to the highway is (a) Toward the east (b) Toward the west (c) Directed vertically (d) Zero

Section 2

- 1) The unit of work in the SI is the (a) newton (b) ft-lb (c) joule (d) both (a) and (c)
- 2) Work is done on an object when it is (a) moved (b) stationary (c) acted upon by a balanced force (d) none of the preceding
- 3) The unit of power in the SI is the (a) newton (b) horsepower (c) joule (d) watt
- 4) If motor A has twice as much horsepower as motor B, then motor A has the power capability to do (a) half the work in twice the time (b) the same work in half the time (c) Twice the work in half the time (d) none of the preceding
- 5) The unit of energy in the SI is the (a) joule (b) newton (c) watt (d) horsepower
- 6) Kinetic energy is the energy of (a) position (b) motion (c) work (d) power
- 7) The combustion of gasoline involves the release of (a) electrical energy (b) Electromagnetic energy (c) radiant energy (d) chemical energy
- 8) The random motion of molecules in a substance is associated with (a) electrical energy (b) heat energy (c) chemical energy (d) all of the preceding
- 9) Energy cannot be (a) transferred (b) conserved (c) created (d) both (a) and (c)
- 10) Mechanical energy is (a) always conserved (b) the same as total energy in all cases (c) the sum of kinetic and potential energies (d) none of the preceding
- 11) A machine can be used to change a force's (a) direction (b) magnitude (c) nature (d) both (a) and (b)
- 12) Efficiency (a) has no units (b) is the same as mechanical advantage (c) may be greater than 1.0, or 100% (d) can be negative
- 13) The gravitational potential energy (a) is independent of height (b) is always positive (c) is independent of path (d) decreases with increasing height
- 14) The form of energy in which mass conversion is significant is (a) electrical (b) gravitational (c) nuclear (d) chemical
- 15) The total energy is conserved in (a) a conservative system (b) a nonconservative system (c) the universe (d) all of the preceding

- 16) A machine (a) can have a mechanical advantage greater than one (b) multiplies the work input (c) can run perpetually (d) is not subject to the conservation of energy
- 17) The time rate of doing work is (a) energy (b) power (c) momentum (d) efficiency
- 18) When the efficiency of a machine is increased (a) the work output increases (b) the work input is increased (c) perpetual motion occurs (d) the total energy is not conserved

Section 3

- 1) A change in momentum may result from (a) an acceleration (b) a force (c) an impulse (d) all of the preceding
- 2) By manipulating the impulse, one can change the (a) force (b) contact time (c) momentum (d) all of the preceding
- 3) For momentum to be conserved there must be an absence of a force that is (a) unbalanced (b) external (c) internal (d) both (a) and (b)
- 4) With constant mass, the conservation of momentum is essentially stated in which of Newton's Laws? (a) First (b) Second (c) Third (d) Gravitation
- 5) Which of the following are conserved in an elastic collision? (a) Momentum (b) Kinetic energy (c) Impulse (d) both (a) and (b)
- 6) Which of the following are conserved in an inelastic collision? (a) Momentum (b) Kinetic energy (c) Impulse (d) both (a) and (b)
- 7) In order to reduce the “string” in catching a hard ball, one usually (a) increases the change in momentum (b) increases the contact force (c) increases the impulse (d) increases the contact time
- 8) Automobile air bags protect passengers during collisions by (a) reducing the impulse (b) decreasing the impulse time and increasing the impulse force (c) increasing the impulse time and decreasing the impulse force (d) decreasing both the impulse time and force
- 9) Padded dashboards in automobiles reduce injury by (a) increasing friction (b) increasing the contact time (c) decreasing friction (d) stopping the passenger more quickly
- 10) The impulse applied to an object is equal to the change in its (a) kinetic energy (b) acceleration (c) momentum (d) velocity
- 11) The impulse is equal to the (a) force times distance (b) mass times acceleration (c) distance divided by force (d) force times time
- 12) Momentum is (a) a vector quantity (b) dependent on mass (c) a function of velocity (d) all of these

- 13) If the velocity of a moving object is doubled without changing the mass, its momentum (a) remains the same (b) is doubled (c) is quadrupled (d) is halved
- 14) Momentum takes into account (a) space and time (b) collisions and heat (c) inertia and motion (d) shape and size
- 15) When objects stick together after collision (a) the momentum is not conserved (b) the momentum is zero (c) the collision is completely inelastic (d) the collision is elastic
- 16) For a system of constant mass, the conservation of momentum is essentially stated in (a) Newton's first law (b) Newton's second law (c) Newton's third law (d) Newton's law of gravitation
- 17) Impulse does not depend on (a) force (b) contact time (c) temperature (d) velocity
- 18) Two balls moving toward each other on a frictionless horizontal surface collided and immediately came to a complete stop. This shows that the balls (a) are perfectly elastic (b) have the same mass (c) had equal amounts of kinetic energy before impact (d) had equal amounts of momentum before impact

Section 4

- 1) At the maximum height of a vertical projection, (a) the velocity is zero (b) the acceleration is zero (c) both (a) and (b) (d) neither (a) nor (b)
- 2) For a projection at an angle, the common factor for the x- and y-components of motion is (a) acceleration (b) speed (c) time (d) direction
- 3) Uniform circular motion requires (a) centripetal acceleration (b) centripetal force (c) tangential velocity (d) all of the preceding
- 4) Centrifugal force is (a) the reaction force to centripetal force (b) a pseudo force (c) the same as centripetal force (d) a requirement for circular motion
- 5) The orbits of the planets have the following shape(s): (a) circle (b) square (c) ellipse (d) a variety of shapes
- 6) Earth has its greatest orbital speed and is closest to the Sun in our (a) summer (b) winter (c) spring (d) fall
- 7) A cannon ball is projected at a 45-degree angle with an initial velocity v . Neglecting air resistance, at its maximum height it will have (a) no velocity (b) a maximum horizontal velocity (c) no vertical velocity (d) vertical acceleration of 9.8 m/s^2
- 8) The braking action of a large jet plane after landing is chiefly due to (a) tire friction (b) mechanical brakes (c) reverse thrust (d) resistance on wing foils
- 9) A projectile (a) has a constant speed in the horizontal direction (b) is always projected in one dimension (c) has no forces acting on it (d) has no vertical acceleration
- 10) An object in uniform circular motion has constant (a) velocity (b) tangential acceleration (c) momentum (d) speed
- 11) The laws of planetary motion were developed by (a) Newton (b) Galileo (c) Brahe (d) Kepler
- 12) Kepler stated that the geometric shape of the orbits of the planets is a(n) (a) circle (b) parabola (c) ellipse (d) rectangle
- 13) A piece of chalk is projected horizontally from the top edge of a table. At the same instant a piece of chalk is dropped from the same table height. (a) both will have the same velocity when they reach the floor (b) the dropped chalk will have the greater

velocity (c) the projected chalk will have the greater velocity (d) the dropped chalk will reach the floor first

14) A vertically projected object (a) has zero acceleration at maximum height (b) has a constant velocity (c) returns to its starting point with the same initial speed (d) has a greater acceleration than a horizontally projected object

15) If air resistance is a factor in a horizontal projection or a projection at an angle, the range of the projectile would be (a) greater (b) less (c) the same

Section 5

1. The force of gravity (a) keeps the moon in orbit (b) causes us to have weight (c) produces ocean tides (d) all of the preceding
2. Which of the following is not a "universal" constant? (a) G (b) l (c) g (d) c , the speed of light in vacuum
3. Ocean tides occur (a) once daily (b) exactly 12 hours apart (c) only in the Southern Hemisphere (d) because of lunar gravitation
4. During a full-moon spring tide, the gravitational attractions of the Sun and moon on the Earth (a) cancel each other (b) are generally in opposite directions (c) produce higher low tides (d) produce very high tides because the moon is closer to the Sun
5. Which planet's discovery was a direct result of using Newton's law of gravitation? (a) Neptune (b) Uranus (c) Planet X (d) Saturn
6. A comet's tail (a) results from lunar attraction (b) is caused by solar gravity (c) extends away from the Sun (d) both (a) and (b)
7. The acceleration due to gravity, g , (a) is a universal constant (b) increases with altitude (c) does not depend on the mass of the Earth (d) does not depend on the mass of an object
8. Compared with its value on the Earth's surface, the acceleration due to gravity at an altitude of one Earth radius is (a) the same (b) two times greater (c) one-half as great (d) one-fourth as great
9. A location in a gravitational field is (a) the gravitational force per unit mass at that point (b) on a line of force (c) the acceleration due to gravity at that point (d) all of the preceding
10. The theory of gravity as being a warping of space-time was proposed by (a) Newton (b) Halley (c) Einstein (d) Lowell
11. To be truly weightless would require (a) micro gravity (b) zero gravity (c) a g of force (d) a gravitational field
12. Standing on Earth, a person experiences how many g 's of force? (a) 1 (b) 1.5 (c) 2 (d) 4

13. If a satellite near the Earth's surface does not have a minimum tangential speed of 8 km/s, it will (a) go into an elliptical orbit (b) go into a circular orbit (c) fall back to Earth (d) escape into outer space
14. Rockets are made more efficient by (a) greater fuel capacities (b) in-flight mass reduction (c) achieving escape velocity on blast-off (d) all of the preceding
15. The weakest fundamental force is the (a) electromagnetic force (b) gravitational force (c) weak nuclear force (d) strong nuclear force
16. At an altitude equal to the Earth's radius, a person would weigh what percentage of his or her weight on Earth? (a) 200% (b) 100% (c) 50% (d) 25%

Section 6

1. A particle (a) has no physical dimensions (b) can be accurately located (c) does not have rotation (d) all of the preceding apply
2. The center of mass (a) always lies within a body (b) applies only to a rigid body (c) is at the center of a uniform sphere (d) both (a) and (b)
3. If every particle of a body has the same instantaneous velocity, it is (a) in translational motion (b) in rotational motion (c) in rolling motion (d) at rest
4. If every particle of a body moves in circles about a fixed axis of rotation, it is (a) in translational motion (b) in rotational motion (c) in rolling motion (d) at rest
5. How many radians are there in one complete rotation? (a) 2 ll (b) 3 ll (c) 4 ll (d) 360
6. The particles in a uniformly rotating body all have the same (a) location (b) angular speed (c) tangential velocity (d) both (b) and (c)
7. The moment of inertia is a measure of (a) rotational speed (b) angular acceleration (c) torque (d) rotational inertia
8. The farther the mass of a body is from the axis of rotation, (a) the smaller its rotational speed (b) the larger the number of radians in a circle (c) the larger the moment of inertia (d) none of the preceding
9. The torque on a body can be increased by increasing the (a) lever arm (b) force (c) inertia (d) both (a) and (b)
10. In the absence of an unbalance torque, a rigid body will (a) remain at rest (b) remain in motion with a constant angular velocity (c) either (a) or (b) (d) none of the preceding
11. A marble in a bowl is in (a) stable equilibrium (b) unstable equilibrium (c) both (a) and (b) (d) neither (a) nor (b)
12. An object in stable equilibrium will remain so as long as its center of gravity is (a) outside the object (b) at the same location as its center of mass (c) inside and above its original base of support (d) none of the preceding
13. The angular momentum of a system is conserved when (a) the torques are balanced

- (b) there is an unbalanced torque (c) there is an angular acceleration (d) none of the preceding
14. A spiraling football is an example of (a) pure translational motion (b) pure rotational motion (c) a nonrigid body (d) the general motion of a rigid body
15. The time rate of change of angular velocity is known as angular (a) momentum (b) rotational velocity (c) acceleration (d) inertia
16. Rotational kinetic energy (a) depends on the mass distribution of a body (b) is equal to $I\omega$ (c) requires the conservation of angular momentum (d) is the same as translational kinetic energy
17. As a planet or a comet approaches the Sun its speed increases so as to maintain constant (a) kinetic energy (b) velocity (c) linear momentum (d) angular momentum about the Sun
18. A circus stilt walker stand balanced on one stilt. He is in (a) stable equilibrium (b) neutral equilibrium (c) unstable equilibrium (d) universal equilibrium

Section 7

1. Which one of the following did not support atomic theory? (a) Aristotle (b) Democritus (c) Gassendi (d) Dalton
2. An atomic species is defined by the number of (a) electrons (b) protons (c) neutrons (d) both (b) and (c)
3. The periodic table was formulated by (a) Democritus (b) Dalton (c) Einstein (d) Mendelieve
4. Elements in a vertical column in the periodic table (a) have the same number of protons (b) form a period (c) have similar chemical properties (d) have similar atomic masses
5. Substances with high melting points generally have (a) ionic bonds (b) covalent bonds (c) polar bonds (d) both (b) and (c)
6. A polar bond is a type of (a) ionic bond (b) covalent bond (c) bond with symmetrical sharing (d) bond involving magnetic poles
7. A liquid has (a) definite shape and volume (b) definite volume but no definite shape (c) no definite shape or volume (d) none of the preceding
8. A plasma, the so-called fourth phase of matter, is (a) a combination of a solid and a liquid (b) a gas dissolved in a liquid (c) a combination of the other three phases of matter (d) a gaseous mixture of electrons and ions
9. Which of the following is not determined by the number of protons in the nucleus of an atom? (a) atomic number (b) name or type of atom (c) number of electrons in the neutral atom (d) mass number
10. A substance in which all the atoms have the same number of protons is called a/an (a) compound (b) element (c) molecule (d) none of these
11. An atom or molecule with a net electrical charge due to the transfer (loss or gain) of one or more electrons is known as a/an (a) isotope (b) polar atom or molecule (c) ion (d) none of these
12. A group of two or more atoms held together by forces called chemical bonds is a (a) molecule (b) compound (c) period (d) family

Section 8

1. A solid with its atoms or molecules in an orderly arrangement is called
(a) amorphous (b) crystalline (c) polymer (d) plastic
2. The black writing material in a pencil is (a) lead (b) ink (c) carbon (d) none of the preceding
3. Units of density are (a) kg/m^3 (b) g/cm^3 (c) both (a) and (b) (d) neither (a) nor (b)
4. A material might be made denser by (a) burning (b) stretching (c) compacting (d) heating
5. Which type of solid is characterized by high melting points? (a) Ionic (b) Molecular (c) Polymer (d) All of the preceding
6. Polymers are composed of (a) plastics (b) ionic molecules (c) alloys (d) monomers
7. All materials are to some extent (a) polymers (b) brittle (c) elastic (d) hard
8. An automobile “fender bender” is an example of (a) elasticity (b) plasticity (c) Hooke’s law (d) sublimation
9. An amorphous solid has (a) a definite melting point temperature (b) an orderly array of particles (c) an X-ray diffraction pattern (d) a random particle arrangement
10. The material with the greatest density is (a) water (b) zinc (c) osmium (d) iron
11. Plastic deformation occurs (a) chiefly in ceramic materials (b) only for metals (c) only in plastics (d) when the elastic limit is reached
12. A solid that consists of covalently bonded atoms such that the solid consists of one large (a) micromolecular (b) macromolecular (c) amorphous (d) ionic
13. In applying a force to a solid it is common to speak of applying a stress, where stress is defined as the (a) applied force (b) force \times area (c) force/area (d) force/volume
14. The geometric pattern or arrangement of particles in a crystalline solid is known as the (a) ionic structure (b) lattice (c) macromolecular pattern (d) none of these
15. A plastic is (a) made of monomers (b) a macromolecular solid (c) a crystalline solid (d) an alloy

16. The alloy bronze is made up of (a) iron and carbon (b) copper and zinc (c) copper and tin (d) chromium and nickel
17. The fundamental repeating units in large molecules are called (a) polymers (b) monomers (c) macromolecules (d) ionics

Section 9

1. Pressure has units of (a) N (b) N-m (c) N/m^2 (d) m/N
2. Pressure may be increased by (a) decreasing the applied force (b) decreasing the area of contact (c) increasing the force and area by the same factor (d) none of the preceding
3. Pressure applied to an enclosed liquid is (a) transmitted undiminished (b) reduced with distance (c) described by an inverse square law (d) both (a) and (c)
4. Pascal's principle is applied in (a) a hydraulic press (b) a garage lift (c) a hydraulic brake system (d) all of the preceding
5. The buoyant force in a liquid (a) increases with depth (b) acts on all surfaces of an immersed object (c) is independent of the liquid's density (d) none of the preceding
6. An object sinks in a liquid when (a) the buoyant force is greater than the object's weight (b) it is completely immersed (c) its density is greater than that of the liquid (d) the weight of the displaced liquid is greater than that of the object
7. A hydraulic jack is an application of (a) Archimedes' principle (b) Bernoulli's principle (c) Pascal's principle (d) Newton's principle
8. The buoyant force on a submerged object (a) depends on the weight of the object (b) is greater in a less dense liquid (c) increases with depth in an incompressible liquid (d) depends on volume of liquid displaced
9. In a full, closed container of a liquid, the pressure does not depend on (a) the shape of the container (b) the liquid's mass density (c) the acceleration due to gravity (d) the depth
10. A mechanical advantage can be obtained by the application of (a) Archimedes' principle (b) Pascal's principle (c) Bernoulli's principle (d) surface tension
11. Liquids (a) have a definite volume (b) have no definite shape (c) are essentially incompressible (d) all of the above
12. A fluid that flows slowly when poured from a container is said to have high (a) buoyancy (b) adhesion (c) viscosity (d) capillary action
13. The pressure at a depth in a liquid depends on the liquid's _____ density. (a) volume (b) shape (c) weight (d) mass

14. Detergents (a) have no effect on surface tension (b) increase surface tension (c) decrease surface tension (d) none of these
15. Viscosity (a) decreases with increasing temperature (b) affects the pressure-depth relationship (c) is a factor in buoyancy (d) causes surface tension
16. The crescent-shaped surface of a liquid is called (a) curve (b) semicircle (c) meniscus (d) lens

Section 10

1. When a quantity of dilute gas in a rigid container is heated, it (a) expands (b) has a pressure reduction (c) loses internal energy (d) none of the preceding
2. When an air-filled balloon is put in a freezer and cooled, the balloon has (a) a pressure increase (b) a pressure reduction (c) a volume decrease (d) both (b) and (c)
3. One atmosphere of pressure will support a column of mercury how tall? (a) 30 cm (b) 76 in (c) 0.76 m (d) 760 in
4. Atmospheric pressure is measured with (a) a thermometer (b) a barometer (c) a pump (c) none of the preceding
5. Hot air rises because it is (a) less dense than the surrounding air (b) contained in a balloon (c) not covered by the gas laws (d) none of the preceding
6. The lungs fill with air (a) when the diaphragm relaxes (b) when the lung pressure is less than atmospheric pressure (c) during exhalation (d) when there is systolic pressure
7. The high pressure of the blood in its vessels is called (a) systolic (b) diastolic (c) barometric (d) atmospheric
8. A normal systolic blood pressure would be (a) 70 torr (b) 80 torr (c) 125 torr (d) 180 torr
9. When the volume of a gas is decreased (a) the pressure must increase (b) the density must increase (c) the temperature must increase (d) Boltzmann's constant changes
10. The "relaxation" pressure of the circulatory system is called (a) barometric pressure (b) diastolic pressure (c) systolic pressure (d) air pressure
11. The heart is effectively a (a) force pump (b) lift pump (c) barometer (d) vacuum cleaner
12. Boyle's gas law states the relationship between pressure and volume of a gas at (a) constant temperature (b) varying temperature (c) constant heat (d) none of these
13. For a balloon to rise, the gas inside must have _____ than the air outside. (a) fewer molecules per unit volume (b) less density (c) less humidity (d) less internal energy

Section 11

1. The period of an SHM oscillation (a) increases with amplitude (b) is equal to $1/f$ (c) has units of hertz (d) is always in phase
2. If the motions of two oscillators were opposite, we say they are (a) in SHM (b) in phase (c) out of phase (d) both (b) and (c)
3. Waves can propagate through (a) matter (b) space (c) time (d) both (a) and (b)
4. A disturbance with particle oscillations parallel to the direction the wave propagation is called a (a) transverse wave (b) longitudinal wave (c) water wave (d) light wave
5. Intensity (a) is the same as energy (b) falls off as $1/r$ (c) has units of $\text{J/s}\cdot\text{m}^2$ (d) none of the preceding
6. The energy of a wave (a) is proportional to the square of its amplitude (b) is equal to Iat (c) falls off as $1/r^2$ (d) all of the preceding
7. When two waves interfere, which of the following add? (a) Displacement (b) Wavelength (c) Phase (d) None of these
8. If the combined waveforms of two identical interfering waves is smaller than that of either wave, the interference is said to be (a) constructive (b) destructive (c) standing (d) both (b) and (c)
9. Standing waves (a) have no motion at all (b) are always out of phase (c) have zero amplitude at the nodal positions (d) can have only one characteristic frequency
10. When driven at resonance, a rope vibrates (a) out of phase (b) at only one possible frequency (c) at only the 2nd harmonic or 2nd overtone (d) at maximum amplitude
11. The propagation of energy through a medium or space from a disturbance is a(n) (a) oscillation (b) vibration (c) wave (d) harmonic
12. If the motions of two oscillators of the same frequency are always in the same direction, we say they are (a) in resonance (b) in phase (c) out of phase (d) destructive

Section 12

1. Which of the following sound frequencies would not be heard by the human ear?
(a) 15 Hz (b) 900 Hz (c) 15000 Hz (d) 19 kHz
2. The speed of sound is (a) independent of temperature (b) generally greater in liquids than in solids (c) on the order of 34 m/s in air (d) none of these
3. Sonar depends on sound (a) reflection (b) refraction (c) reverberation (d) resonance
4. Concert halls experience sound problems because of (a) multiple reflections (b) reverberant sound (c) refraction (d) both (a) and (b)
5. If a sound source and an observer both move with the same constant velocity, the frequency heard by the observer relative to the source frequency would be (a) higher (b) lower (c) the same
6. The speed of sound in air is 340 m/s. If a plane flies at a speed of 510 m/s, it has a Mach number of (a) 1.5 (b) 2.0 (c) 2.5 (d) 2.7
7. The bel unit is a comparative measure of sound (a) frequency (b) quality (c) intensity level (d) none of these
8. A pleasant musical sound is said to be (a) consonant (b) in octave (c) loud (d) dissonant
9. The upper limit of the frequency range of human hearing is (a) 20dB (b) 120dB (c) 20 kHz (d) 10^9 Hz
10. The speed of sound in air on a day when the air temperature is 25 degree C is (a) 331 m/s (b) 346 m/s (c) 352 m/s (d) 360 m/s
11. A person hears thunder 4 seconds after seeing a lightning flash. The lightning was approximately how far away? (a) 1.3 km (b) 1.5 km (c) 2.6 km (d) 3.0 km
12. The Doppler effect (a) is caused by resonance (b) occurs for a person riding in a car with the car horn blowing (c) gives rise to beats (d) is used in radar
13. A change in the sound level intensity from 100 dB to 70 dB corresponds to a decrease in sound intensity by a factor of (a) 10 (b) 100 (c) 1,000 (d) 10,000

14. A Doppler "blue shift" occurs when (a) the source is moving away from a stationary observer (b) an observer is moving away from a stationary source (c) the observer and source are moving towards each other (d) the observer and source are stationary
15. For the Doppler effect to occur, there must be (a) a moving source of sound (b) a moving listener (c) relative motion between a source of sound and listener (d) all of these

Section 13

1. Temperature is (a) a measure of heat (b) a relative measure of hotness and coldness (c) internal energy in transit (d) both (b) and (c)
2. Heat is (a) a form of energy (b) energy transferred because of a temperature difference (c) internal energy in transit (d) all of the preceding
3. Thermal expansion, or an increase in dimensions with increasing temperature, occurs (a) in most substances (b) in very few substances (c) only in metals (d) both (b) and (c)
4. When a bimetallic strip is heated, it bends toward the metal with the (a) greater thermal expansion (b) smaller thermal expansion (c) greater specific heat (d) lower specific heat
5. The degree Fahrenheit is equal to the unit interval on (a) the Celsius scale (b) the Kelvin scale (c) both (a) and (b) (d) none of the preceding
6. Which of the following is the highest temperature? (a) 0°F (b) 0°C (c) 0°K (d) all are equal
7. Which of the following heat units is neither the largest nor the smallest? (a) kilocalorie (b) Btu (c) calorie (d) all are equal
8. A Btu is equivalent to about how many food Calories? (a) $\frac{1}{2}$ (b) $\frac{1}{4}$ (c) $\frac{1}{6}$ (d) $\frac{1}{8}$
9. Which of the following units could be used for specific heat? (a) $\text{Cal/g}^{\circ}\text{C}$ (b) kcal/kg-K (c) Btu/lb-degree F (d) all of the preceding
10. The specific heat of substance A is ten times greater than that of substance B. If equal amounts of heat are added to equal masses of the substances, the temperature increase of substance A is (a) the same as that of B (b) ten times greater than that of B (c) $\frac{1}{10}$ that of B (d) none of the preceding
11. The smallest temperature unit is (a) degree Fahrenheit (b) degree Celsius (c) the Kelvin (d) all are the same
12. The human temperature sense is associated with (a) sight (b) hearing (c) smell (d) touch

13. A cucumber has a food energy value of 5 Calories. If all this energy could be transferred to a kilogram of water, it would raise the temperature by (a) 5°F (b) 5K (c) 10°C (d) 50°C
14. The specific heat of water is 1.0 kcal/kg•°C. If the temperature of 2.0 kg of water is lowered by 10°C, the amount of heat removed would be (a) 2 kcal (b) 5 kcal (c) 10 kcal (d) 20 kcal
15. One Kelvin unit is equivalent to (a) one degree Fahrenheit (b) 1.8 degree Celsius (c) 9/5 degree Fahrenheit (d) one BTU
16. Absolute zero is (a) -273 °C (b) -273 K (c) 273 K (d) 273°F

Section 14

1. A method of heat transfer that generally does not involve mass transfer is
(a) conduction (b) convection (c) radiation (d) both (a) and (c)
2. A roaring fire transfers heat to a person sitting nearby chiefly by (a) conduction
(b) convection (c) radiation (d) both (a) and (b)
3. The energy associated with a phase change is called (a) latent heat (b) specific heat
(c) radiation (d) none of the preceding
4. A direct change from the solid phase to the gaseous phase is called (a) condensation
(b) evaporation (c) sublimation (d) boiling
5. Boiling starts in a heated liquid when the vapor pressure in formed bubbles is (a)
negative (b) zero (c) greater than one atmosphere (d) below the triple-point pressure
6. The freezing point of water is decreased by (a) the addition of more water (b) pressure
(c) dissolved table salt (d) both (b) and (c)
7. Heat transfer takes place because of a difference in (a) potential energy (b) heat
content (c) specific heat (d) temperature
8. Radiation is a method of heat transfer by means of (a) convection currents (b)
molecular interaction (c) electromagnetic waves (d) all of these
9. Heating in a vacuum can take place by (a) conduction (b) convection (c) radiation
10. Sunlight feels warm on the skin primarily because of (a) visible radiation (b)
microwaves (c) ultra-violet radiation (d) infrared radiation
11. Ice, water, and steam coexist at the (a) melting point (b) dew point (c) boiling point
(d) triple point
12. Monsoons occur as a result of (a) conduction cycles (b) convection cycles (c)
radiation cycles (d) thermal insulation

Section 15

1. A heat engine converts (a) work to heat energy (b) heat energy to work (c) heat from a low-temperature reservoir to heat in a high-temperature reservoir (d) none of the preceding
2. The work output of a heat engine is equal to (a) the work input (b) the heat input (c) the heat output (d) the heat input minus the heat output
3. Thermal efficiency is equal to the ratio of (a) work out/heat in (b) heat out/heat in (c) heat in/heat out (d) heat out/work out
4. A heat engine with 40 percent thermal efficiency has a heat input of 100 J per cycle, the heat output of the engine is (a) 40 J (b) 50 J (c) 80 J (d) none of the preceding
5. According to the first law of thermodynamics, if heat is added to a closed system, it goes into (a) entropy (b) work (c) internal energy (d) work and/or internal energy
6. The second law of thermodynamics states that (a) a cyclic heat engine cannot convert heat completely to work (b) a cyclic heat engine cannot have 100 percent efficiency (c) heat will not flow spontaneously from a colder body to a hotter body (d) all of the preceding
7. The heat output of a heat pump is equal to (a) work input (b) heat input (c) sum of (a) and (b) (d) none of the preceding
8. For a refrigerator, the high-temperature reservoir is (a) the freezer compartment (b) the room (c) the inside of the refrigerator (d) the refrigerator compress
9. A heat engine with 100% efficiency would not violate the (a) first law (b) second law (c) third law
10. The difference between a diesel engine and a gasoline engine is (a) the type of fuel used (b) the type of ignition (c) cycle processes (d) all of these
11. For every natural process, the entropy of the universe (a) decreases (b) remains constant (c) is destroyed in part (d) increases
12. Entropy is a measure of (a) thermal efficiency (b) internal energy (c) the capability to do work (d) temperature

Section 16

1. Electric charge (a) is not a fundamental property (b) is given an arbitrary sign designation (c) always experiences an attractive force (d) is found associated only with electrons
2. The electric force between two charged particles (a) is repulsive for unlike charges (b) varies as $1/r$ (c) depends only on the magnitudes of the charges (d) is much, much greater than the gravitational force
3. An insulator may be electrostatically charged by (a) friction (b) contact (c) induction (d) all of these
4. Electrostatic charging (a) occurs best on dry days (b) must be done with a conductor (c) does not involve a transfer or movement of charge (d) none of the preceding
5. Lightning takes place by (a) intracloud discharges (b) cloud-to-cloud discharges (c) cloud to ground discharges (d) all of these
6. Lightning rods prevent damage by making contact with (a) streamers (b) stepped leaders (c) return strokes (d) dart leaders
7. The electric field has units of (a) m/s (b) N-m (c) N/C (d) none of these
8. Electric fields are represented graphically by (a) dots (b) lines of force (c) arrows that point in the direction of the force on a negative charge (d) a series of straight lines
9. Electric potential is (a) the force per charge (b) the same as electric potential energy (c) the electric potential energy per charge (d) given by Coulomb's law
10. Electric potential energy is given by (a) Coulomb's law (b) the law of charges (c) electric field lines (d) charge times voltage
11. Electric charge is measured in units of (a) volts (b) coulombs (c) newtons (d) de Graaffs
12. Electrostatic charges can be placed on an object by (a) friction (b) contact (c) induction (d) all of these

Section 17

1. White light is (a) fluorescent (b) ultraviolet (c) waves with only magnetic field (d) polychromatic
2. The process of an atom absorbing radiation of one wavelength and emitting another is called (a) interference (b) incandescence (c) fluorescence (d) polarization
3. When two waves interfere in phase, the result is (a) fluorescence (b) decreased wave amplitude (c) destructive interference (d) none of the preceding
4. What is "destroyed" in destructive interference? (a) Wave form (b) Energy (c) Electric and magnetic fields (d) All of the preceding
5. Waves may be deviated from a straight-line path by (a) reflection (b) refraction (c) diffraction (d) all of these
6. Which type of wave would be diffracted by a door opening? (a) Sound waves (b) AM radio waves (c) FM radio waves (d) All of these
7. Light may be polarized by (a) absorption (b) reflection (c) scattering (d) all of these
8. The polarizing direction of polarizing sunglasses is (a) vertical (b) horizontal (c) at a 45 degree angle (d) immaterial
9. What type of light can be coherent? (a) Spontaneous emission (b) Monochromatic and in phase (c) Narrow beam divergence (d) Monochromatic only
10. When the temperature of an incandescent solid is increased, (a) the emitted light intensity is less (b) there is an ultraviolet catastrophe (c) the most intense spectral component is shifted to a higher frequency (d) nothing changes
11. The dual nature of light refers to the (a) quantum properties of light (b) wave and particle characteristic properties of light (c) frequency and wavelength properties of light (d) none of these
12. The excited mercury vapor in a fluorescent lamp emits what type of radiation? (a) Infrared (b) Ultraviolet (c) Visible (d) Heat
13. The bending of waves around corners is called (a) interference (b) diffraction (c) reflection (d) polarization
14. Polarization involves (a) orientation of field vectors (b) bending of light around corners (c) interference (d) longitudinal waves

15. Incandescent lamps produce predominantly (a) monochromatic light (b) polarized light (c) visible light (d) infrared radiation
16. Light in which the electric field is in only one direction is (a) monochromatic (b) polarized (c) produced by interference (d) not an electromagnetic wave
17. What type of diffraction is observed in everyday activities (a) light (b) sound (c) electron (d) X-ray
18. TV's sometimes flutter when airplanes fly over as a result of (a) diffraction (b) reflection (c) interference (d) both (b) and (c) (e) both (a) and (c)

Section 18

1. A light ray is a line drawn perpendicular to (a) a wavelength (b) a wave front (c) a beam (d) none of the preceding
2. For ray reflection from a surface, (a) the angle of reflection equals the angle of incidence (b) the reflection angle is measured from a normal to the surface (c) all the rays lie in the same plane (d) all of these
3. The law of reflection applies for (a) specular reflection (b) diffuse reflection (c) irregular reflection (d) all of these
4. A refracted ray is bent away from the normal when entering which type of medium? (a) air to water (b) less optically dense (c) more optically dense (d) all of these
5. In refraction, which of the following wave properties is unchanged? (a) frequency (b) wavelength (c) speed (d) all of these
6. If a medium has a critical angle of 43° , which of the following angles of incidence would give refraction? (a) 40° (b) 44° (c) 45° (d) none of these
7. Total internal reflection could occur for light in which of the following media transitions? (a) vacuum to glass (b) water to air (c) glass to water (d) both (b) and (c)
8. In most transparent materials, which color of light has the greatest angle of refraction from the incident ray direction? (a) red (b) green (c) yellow (d) blue
9. Dispersion is a factor in (a) a diamond's fire (b) the rainbow (c) chromatic aberration (d) all of these
10. A spherical converging lens (a) is free of aberrations (b) cannot form images on a screen (c) is thicker at its center than at its periphery
11. Lens aberrations give rise to (a) external reflection (b) internal reflections (c) a diamond's brilliance (d) blurred images
12. The critical angle for a water-air interface is about 48° . Light will be transmitted from the water for an angle of incidence of (a) 60° (b) 52° (c) 48° (d) 44°
13. Fiber optics is based on (a) diffuse reflection (b) dispersion (c) total internal reflection (d) diverging mirrors

14. Ray optics is a convenient way to represent (a) interference (b) diffraction (c) reflection (d) wavelength
15. The “beam” of a flashlight is seen as a result of (a) diffuse reflection (b) refraction (c) dispersion (d) internal reflection
16. Monochromatic light transmitted into a prism cannot be (a) refracted (b) totally internally reflected (c) dispersed (d) reflected by 180°
17. Dispersion is responsible for (a) a diamond’s brilliance (b) diffuse reflection (c) spherical aberration (d) chromatic aberration
18. A lens thicker at the center than at the edge is called a _____ lens. (a) converging (b) convex (c) diverging (d) both (a) and (b)

Section 19

1. Color vision results from photosensitive cells called (a) pupils (b) rods (c) cones (d) none of these
2. A visual defect that occurs naturally with age is (a) astigmatism (b) color blindness (c) nearsightedness (d) not being able to see near objects clearly
3. Which of the following is *not* an additive primary color? (a) Red (b) Green (c) Yellow (d) Blue
4. Which of the following is *not* a subtractive primary color? (a) Cyan (b) Green (c) Magenta (d) Yellow
5. A simple microscope magnifies by (a) internal reflection (b) refractively widening the angle of view (c) reducing the accommodation (d) affecting the rod cells in the retina
6. An upright image is seen when looking through (a) a terrestrial telescope (b) an astronomical telescope (c) a Galilean telescope (d) both (a) and (c)
7. Light with wavelengths greater than 600nm appears to have the general color of (a) blue (b) green (c) yellow (d) red
8. The sky appears blue as a result of (a) selective absorption (b) selective reflection (c) selective transmission (d) preferential scattering
9. The film of a camera corresponds to what part of the eye? (a) aperture (b) retina (c) cornea (d) iris
10. Rayleigh scattering explains (a) color vision (b) the blueness of the sky (c) additive color production (d) subtractive color production
11. Various types of telescope, use (a) visible light (b) radio waves (c) infrared radiation (d) all of the preceding
12. In the late evening, no color is seen because of lack of stimulation of (a) rods (b) cones (c) cornea (d) crystalline lens

Section 20

1. The catastrophe of the ultraviolet catastrophe was (a) a shift or change in color with temperature (b) a violation of the conservation of energy (c) the emission of thermal radiation (d) none of these
2. Planck's hypothesis (a) explained the photoelectric effect (b) justified the ultraviolet catastrophe (c) required classical wave theory (d) allowed only discrete energies for thermal oscillators
3. Classical theory predicted (a) photocurrent to be proportional to light intensity (b) electron energy to depend on light frequency, but not on intensity (c) no photoemission below a certain light frequency regardless of intensity (d) both (b) and (c)
4. For a photon to cause the emission of an electron, it must have a frequency (a) equal to Planck's constant (b) in the visible region (c) greater than the threshold frequency (d) none of the preceding
5. For a hydrogen atom, which of the following quantum states has the greatest energy value? (a) $n = 1$ (b) $n = 2$ (c) $n = 5$ (d) $n = 10$
6. When the electron of a hydrogen atom moves from an excited state to the ground state, (a) a photon is emitted (b) thermal energy is absorbed (c) several photons of different frequencies are emitted (d) the electron has a positive energy value
7. The *s* in the acronym laser stands for (a) simple (b) spontaneous (c) specific (d) stimulated
8. A laser (a) amplifies light (b) produces monochromatic light (c) produces coherent light (d) all of these
9. The first laser was made by (a) Charles Townes (b) Theodore Maiman (c) Gordon Gould (d) Nikolai Basov and Aleksander Prokhorov (e) H. G. Wells
10. The first laser emitted (a) pulses of 694 nm red light (b) a continuous (c) pulses of white light from a helical flashlamp (d) spontaneous emission
11. Laser light is which of the following (a) coherent (b) stimulated emission (c) monochromatic (d) a, b and d (e) c and d
12. Which of the following is NOT a laser application (a) printing computer output (b) stimulating rainfall from clouds (c) making very precise measurements (d) playing compact disc audio recordings (e) engraving wood

13. The coherence of laser light is important for (a) no practical applications (b) drilling holes (c) getting laser light to pass through air (d) holography (e) none of above
14. Which important laser emits light in the visible range, 400 to 700 nm? (a) argon ion (b) nitrogen (c) carbon dioxide (d) neodymium YAG (e) chemical
15. Population inversion has (a) more atoms in lower energy level (b) less atoms in higher energy level (c) more atoms in higher energy level (d) the same number of atoms in all energy level
16. A carbon dioxide laser has a nominal wavelength of 10.6 micrometers. What is its frequency? (a) 300,000 hertz (b) 2.8×10^{13} hertz (c) 1.06 gigahertz (d) 2.8×10^{10} hertz (e) none of above
17. The quantum hypothesis was introduced by (a) Einstein (b) Planck (c) Bohr (d) DeBroglie
18. The photoelectric effect was explained by (a) Planck (b) Einstein (c) Bohr (d) DeBroglie
19. When a hydrogen electron is excited to a higher energy level, (a) it must be in the ground state (b) a photon of any frequency may be absorbed (c) a photon must be emitted (d) energy is absorbed
20. Light amplification in a laser is due to (a) spontaneous emission (b) the photoelectric effect (c) stimulated emission (d) the ultraviolet catastrophe
21. In a stimulated emission process, an excited atom is struck by a photon of the same energy of the allowed transition, and the atom emits an identical photon. After emission, the two photons (a) have the same frequency (b) are emitted in the same direction (c) are in phase (d) all of these
22. Laser light is (a) chaotic (b) incoherent (c) coherent (d) polychromatic
23. The most important component in a laser is (a) pencil (b) active medium (c) resistor (d) capacitor

Answers for Multiple Choice Questions:

Section 1:

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|------|------|-------|-------|-------|
| 1. b | 5. b | 9. c | 13. c | 17. d |
| 2. c | 6. d | 10. c | 14. b | 18. d |
| 3. c | 7. c | 11. b | 15. a | |
| 4. c | 8. b | 12. b | 16. d | |

Section 2:

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|------|------|-------|-------|-------|
| 1. c | 5. a | 9. c | 13. c | 17. b |
| 2. a | 6. b | 10. c | 14. c | 18. a |
| 3. d | 7. d | 11. d | 15. d | |
| 4. b | 8. b | 12. a | 16. a | |

Section 3:

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|------|------|-------|-------|-------|
| 1. d | 5. d | 9. b | 13. b | 17. c |
| 2. d | 6. a | 10. c | 14. c | 18. d |
| 3. d | 7. d | 11. d | 15. c | |
| 4. a | 8. c | 12. d | 16. a | |

Section 4:

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|------|------|------|-------|-------|
| 1. a | 4. b | 7. c | 10. d | 13. c |
| 2. c | 5. c | 8. c | 11. d | 14. c |
| 3. d | 6. b | 9. a | 12. c | 15. b |

Section 5:

- | | | | |
|------|------|-------|-------|
| 1. d | 5. a | 9. b | 13. c |
| 2. c | 6. c | 10. c | 14. b |
| 3. d | 7. d | 11. b | 15. b |
| 4. b | 8. d | 12. a | 16. d |

Section 6:

- | | | | | |
|------|------|-------|-------|-------|
| 1. d | 5. a | 9. d | 13. a | 17. d |
| 2. c | 6. b | 10. c | 14. d | 18. c |
| 3. a | 7. d | 11. a | 15. c | |
| 4. b | 8. c | 12. c | 16. a | |

Section 7:

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|------|------|------|-------|
| 1. a | 4. c | 7. b | 10. b |
| 2. b | 5. a | 8. d | 11. c |
| 3. d | 6. b | 9. d | 12. a |

Section 8:

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|------|------|-------|-------|-------|
| 1. b | 5. a | 9. d | 13. c | 17. b |
| 2. c | 6. d | 10. c | 14. b | |
| 3. c | 7. c | 11. d | 15. a | |
| 4. c | 8. b | 12. b | 16. c | |

Section 9:

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|------|------|-------|-------|
| 1. c | 5. b | 9. a | 13. c |
| 2. b | 6. c | 10. b | 14. c |
| 3. a | 7. c | 11. d | 15. a |
| 4. d | 8. d | 12. c | 16. c |

Section 10:

- | | | | | |
|------|------|------|-------|-------|
| 1. d | 4. b | 7. a | 10. b | 13. b |
| 2. d | 5. a | 8. c | 11. a | |
| 3. c | 6. b | 9. a | 12. a | |

Section 11:

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|------|------|------|-------|
| 1. b | 4. b | 7. a | 10. d |
| 2. c | 5. c | 8. b | 11. c |
| 3. d | 6. d | 9. c | 12. b |

Section 12:

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|------|------|------|-------|-------|
| 1. a | 4. d | 7. c | 10. b | 13. c |
| 2. d | 5. c | 8. a | 11. a | 14. c |
| 3. a | 6. a | 9. c | 12. d | 15. c |

Section 13:

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|------|------|-------|-------|
| 1. b | 5. b | 9. d | 13. b |
| 2. d | 6. b | 10. c | 14. d |
| 3. a | 7. b | 11. a | 15. c |
| 4. b | 8. b | 12. d | 16. a |

Section 14:

- | | | | |
|------|------|------|-------|
| 1. d | 4. c | 7. d | 10. d |
| 2. c | 5. c | 8. c | 11. d |
| 3. a | 6. d | 9. c | 12. b |

Section 15:

- | | | | |
|------|------|------|-------|
| 1. b | 4. d | 7. c | 10. d |
| 2. d | 5. d | 8. b | 11. d |
| 3. a | 6. d | 9. a | 12. c |

Section 16:

- | | | | |
|------|------|------|-------|
| 1. b | 4. a | 7. c | 10. d |
| 2. d | 5. d | 8. b | 11. b |
| 3. d | 6. b | 9. c | 12. d |

Section 17:

- | | | | | |
|------|------|-------|-------|-------|
| 1. d | 5. d | 9. b | 13. b | 17. b |
| 2. c | 6. d | 10. c | 14. a | 18. d |
| 3. d | 7. d | 11. b | 15. d | |
| 4. a | 8. a | 12. b | 16. b | |

Section 18:

- | | | | | |
|------|------|-------|-------|-------|
| 1. b | 5. a | 9. d | 13. c | 17. d |
| 2. d | 6. a | 10. c | 14. c | 18. d |
| 3. d | 7. d | 11. d | 15. a | |
| 4. b | 8. d | 12. d | 16. c | |

Section 19:

- | | | | |
|------|------|------|-------|
| 1. c | 4. b | 7. d | 10. b |
| 2. d | 5. b | 8. d | 11. d |
| 3. c | 6. d | 9. b | 12. b |

Section 20:

- | | | | |
|------|-------|-------|-------|
| 1. d | 7. d | 13. d | 19. d |
| 2. d | 8. d | 14. a | 20. c |
| 3. a | 9. b | 15. c | 21. d |
| 4. c | 10. a | 16. b | 22. c |
| 5. d | 11. e | 17. b | 23. b |
| 6. a | 12. b | 18. b | |

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