**ATTENTION: All Division I students, continue through question 40.**
**All Division II students, START HERE. Numbers 1-10 on your answer sheet should remain blank. Your first answer should be number 11.**

11. A cart is initially moving at 0.5 m/s along a track. The cart comes to rest after traveling 1 m. The experiment is repeated on the same track, but now the cart is initially moving at 1 m/s. How far does the cart travel before coming to rest?

(a) 1 m (b) 2 m (c) 3 m (d) 4 m (e) 8 m

12. The definition of average velocity is

(a) the average acceleration multiplied by the time.
(b) distance traveled divided by the time.
(c) $\frac{1}{2}\left(v_f + v_0\right)$.
(d) radius multiplied by angular velocity.
(e) displacement divided by the time.

13. A student weighing 500 N stands on a bathroom scale in the school's elevator. When the scale reads 520 N, the elevator must be

(a) accelerating upward.
(b) accelerating downward.
(c) moving upward at a constant speed.
(d) moving downward at a constant speed.
(e) at rest.

14. An object moves to the East across a frictionless surface with constant speed. A person then applies a constant force to the North on the object. What is the resulting path that the object takes?

(a) A straight line path partly Eastward, partly Northward
(b) A straight line path totally to the North
(c) A parabolic path opening toward the North
(d) A parabolic path opening toward the East
(e) An exponential path opening upward toward the North

Two identical mass objects are launched with the same speed from the same starting location. Object 1 is launched at an angle of $30^0$ above the horizontal while Object 2 is launched at an angle of $60^0$ above the horizontal. Ignore air resistance and consider the flight of each object from launch until it returns to the same launch height above the ground. Questions 15 and 16 refer to this situation.

15. Which object returns to the starting height with the greatest speed?

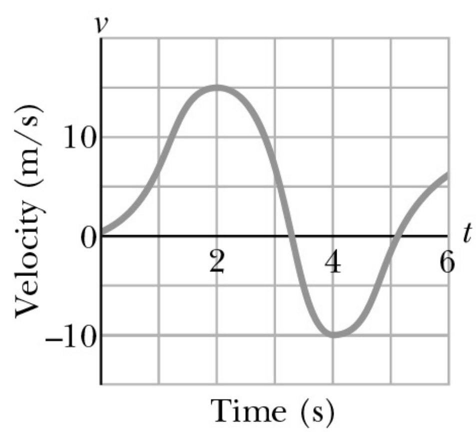
    (a) Object 1 since it keeps a lower trajectory.
    (b) Object 2 since it is in the air for a longer time.
    (c) Object 2 since there is more work done on the object during flight
    (d) The speeds are the same.
    (e) It cannot be determined without more information.

16. Which object experiences the greatest change in the linear momentum?

    (a) Object 1 since it has a higher final speed.
    (b) Object 2 since it has a higher final speed.
    (c) Object 2 since it is in the air for a longer time.
    (d) The change in momentum is the same for each.
    (e) It cannot be determined without more information.

17. A toy car moves along the *x*-axis according to the velocity versus time curve shown to the right. When does the car have zero acceleration?

    (a) at 2 and 4 seconds
    (b) at approximately 3.0 seconds
    (c) at approximately 3.3 and 5.1 seconds
    (d) the acceleration is always zero
    (e) at no time



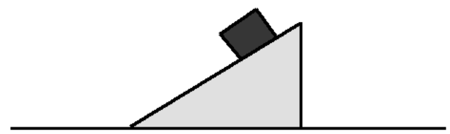

18. In which one of the following situations is the net force constantly zero on the object?

    (a) A mass attached to a string and swinging like a pendulum.
    (b) A stone falling freely in a gravitational field.
    (c) An astronaut floating in the International Space Station.
    (d) A snowboarder riding down a steep hill.
    (e) A skydiver who has reached terminal velocity.

19. What net force is necessary to keep a 1.0 kg puck moving in a circle of radius 0.5 m on a horizontal frictionless surface with a speed of 2.0 m/s?

(a) 0 N (b) 2.0 N (c) 4.0 N (d) 8.0 N (e) 16 N

20. A large wedge rests on a horizontal frictionless surface, as shown. A block starts from rest and slides down the inclined surface of the wedge, which is rough. During the motion of the block, the center of mass of the block and wedge system



(a) does not move.
(b) moves vertically with increasing speed.
(c) moves horizontally with constant speed.
(d) moves horizontally with increasing speed.
(e) moves both horizontally and vertically.

21. A box slides to the right across a horizontal floor. A person called Ted exerts a force $T$ to the right on the box. A person called Mario exerts a force $M$ to the left, which is half as large as the force $T$. Given that there is friction $f$ and the box accelerates to the right, rank the sizes of these three forces exerted on the box.

(a) $f < M < T$
(b) $M < f < T$
(c) $M < T < f$
(d) $f = M < T$
(e) It cannot be determined.

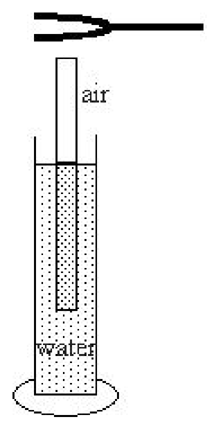
22. A mass $m$ is pulled outward until the string of length $L$ to which it is attached makes a 90-degree angle with the vertical. The mass is released from rest and swings through a circular arc. What is the tension in the string when the mass swings through the bottom of the arc?

(a) 0 (b) $mg$ (c) $2mg$ (d) $3mg$ (e) It cannot be determined.

23. The period of a mass-spring system undergoing simple harmonic oscillation is $T$. If the amplitude of the mass-spring system's motion is doubled, the period will be

(a) ¼ $T$ (b) ½ $T$ (c) $T$ (d) $2T$ (e) $4T$

24. A resonance occurs with a tuning fork and an air column of size 39 cm. The next highest resonance occurs with an air column of 65 cm. What is the frequency of the tuning fork? Assume that the speed of sound is 343 m/s.



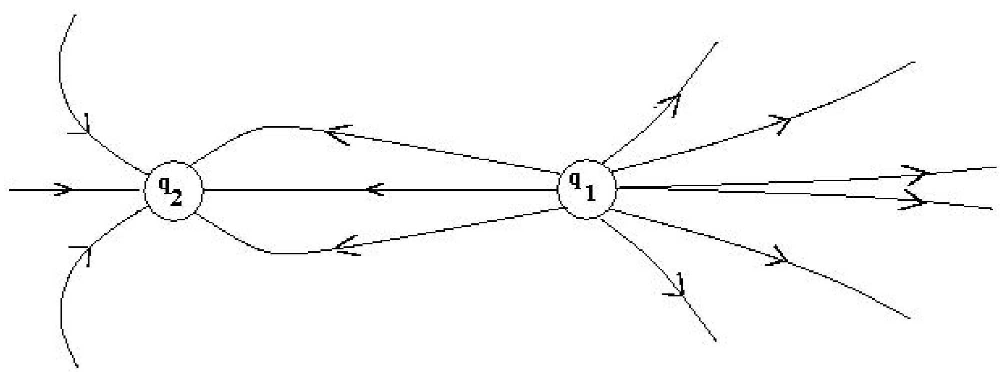

(a) 329.8 Hz
(b) 527.7 Hz
(c) 659.6 Hz
(d) 879.5 Hz
(e) 1319 Hz

25. If two protons are spaced by a distance R, what is the ratio of the gravitational force that one proton exerts on the other to the electric force that one proton exerts on the other? That is,

$$F_{gravity}/F_{electric} =$$

(a) $\approx 10^{-8}$ (b) $\approx 10^{-16}$ (c) $\approx 10^{-20}$ (d) $\approx 10^{-36}$ (e) $\approx 10^{-43}$

26. For the diagram shown below, what is the ratio of the charges $q_2/q_1$, where the diagram shown has a representation of the field lines in the space near the charges.




(a) $-3/2$ (b) $-2/3$ (c) $2/3$ (d) $3/2$ (e) 1

27. A junior Thomas Edison wants to make a brighter light bulb. He decides to modify the filament. How should the filament of a light bulb be modified in order to make the light bulb produce more light at a given voltage?

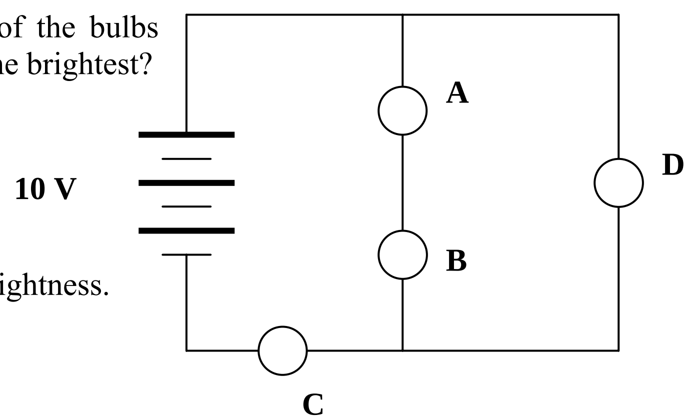
(a) Increase the resistivity only.
(b) Increase the diameter only.
(c) Decrease the diameter only.
(d) Decrease the diameter and increase the resistivity.
(e) Increase the length only.

28. Which statement about a system of point charges that are fixed in space is necessarily true?

(a) If the potential energy of the system is negative, net positive work by an external agent is required to take the charges in the system back to infinity.
(b) If the potential energy of the system is positive, net positive work is required to bring any new charge not part of the system in from infinity to its final resting location.
(c) If the potential energy of the system is zero, no negative charges are in the configuration.
(d) If the potential energy of the system is negative, net positive work by an external agent was required to assemble the system of charges.
(e) If the potential energy of the system is zero, then there is no electric force anywhere in space on any other charged particle not part of the system.

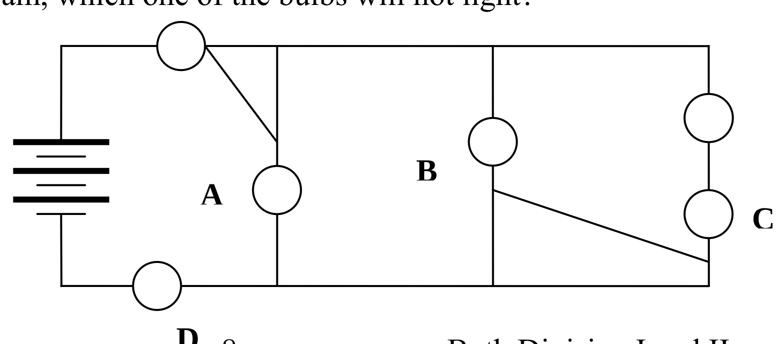
29. In the circuit diagram below, all of the bulbs are identical. Which bulb will be the brightest?

(a) A
(b) B
(c) C
(d) D
(e) The bulbs all have the same brightness.




30. In the following circuit diagram, which one of the bulbs will not light?

(a) A
(b) B
(c) C
(d) D
(e) They all light.



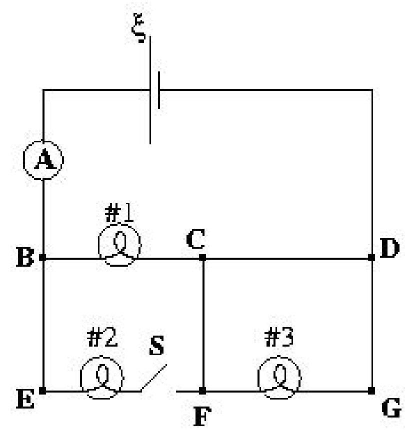
31. James Clerk Maxwell's great contribution to electromagnetic theory was his idea that

(a) work is required to move a magnetic pole through a closed path surrounding a current.
(b) a time-changing electric field acts as a current and produces a magnetic field.
(c) the speed of light could be determined from simple electrostatic and magnetostatic experiments and finding the values of $\mu_o$ and $\varepsilon_o$.
(d) the magnetic force on a moving charge particle is perpendicular to both its velocity and the magnetic field.
(e) magnetism could be explained in terms of circulating currents in atoms.

32. What does LASER stand for?

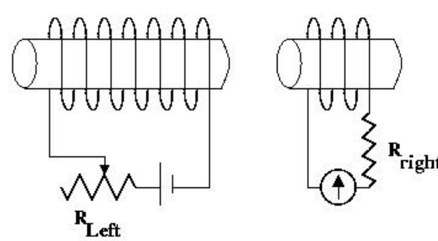
(a) Light Amplification by Simulated Emission of Radiation
(b) Light Amplification by Stimulated Emission of Radiation
(c) Light Amplification by Simultaneous Emission of Radiation
(d) Light Amplification by Systematic Emission of Radiation
(e) Light Amplification by Serendipitous Emission of Radiation

33. For the circuit shown, the ammeter reading is initially *I*. The switch in the circuit then is closed. Consequently:




(a) The ammeter reading decreases.
(b) The potential difference between *E* and *F* increases.
(c) The potential difference between *E* and *F* stays the same.
(d) Bulb #3 lights up more brightly.
(e) The power supplied by the battery decreases.

34. For the solenoids shown in the diagram (which are assumed to be close to each other), the resistance of the left-hand circuit is slowly increased. In which direction does the ammeter needle (indicating the direction of conventional current) in the right-hand circuit deflect in response to this change?




(a) The needle deflects to the left.
(b) The needle deflects to the right.
(c) The needle oscillates back and forth.
(d) The needle rotates in counterclockwise circles.
(e) The needle never moves.

35. Two objects labeled K and L have equal mass but densities $0.95D_0$ and $D_0$, respectively. Each of these objects floats after being thrown into a deep swimming pool. Which is true about the buoyant forces acting on these objects?

(a) The buoyant force is greater on Object K since it has a lower density and displaces more water.
(b) The buoyant force is greater on Object K since it has lower density and lower density objects always float "higher" in the fluid.
(c) The buoyant force is greater on Object L since it is denser than K and therefore "heavier."
(d) The buoyant forces are equal on the objects since they have equal mass.
(e) Without knowing the specific gravity of the objects, nothing can be determined.

36. A driveway is 22.0 m long and 5.0 m wide. If the atmospheric pressure is $1.0 \times 10^5$ Pa, what force does the atmosphere exert on the driveway?

(a) $9.09 \times 10^{-8}$ N
(b) $1.1 \times 10^{-3}$N
(c) 909 N
(d) 4545 N
(e) $1.1 \times 10^7$ N

37. A place of zero displacement on a standing wave is called

(a) an antinode.
(b) a node.
(c) the amplitude.
(d) the wavenumber.
(e) the harmonic.

38. Absolute zero is best described as that temperature at which

(a) water freezes at standard pressure.
(b) water is at its triple point.
(c) the molecules of a substance have a maximum kinetic energy.
(d) the molecules of a substance have a maximum potential energy.
(e) the molecules of a substance have minimum kinetic energy.

39. A mass of material exists in its solid form at its melting temperature $10^0 C$. The following processes then occur to the material:

Process 1: An amount of thermal energy $Q$ is added to the material and ¾ of the material melts.
Process 2: An identical additional amount of thermal energy $Q$ is added to the material and the material is now a liquid at $50^0$ C.

What is the ratio of the latent heat of fusion to the specific heat of the liquid for this material?

(a) $80^0 C$
(b) $60^0 C$
(c) $40^0 C$
(d) $20^0 C$
(e) More information is needed to answer this question.

40. Which is not true of an isochoric process on an enclosed ideal gas in which the pressure decreases?

(a) The work done is zero.
(b) The internal energy of the gas decreases.
(c) The heat is zero.
(d) The rms speed of the gas molecules decreases.
(e) The gas temperature decreases.