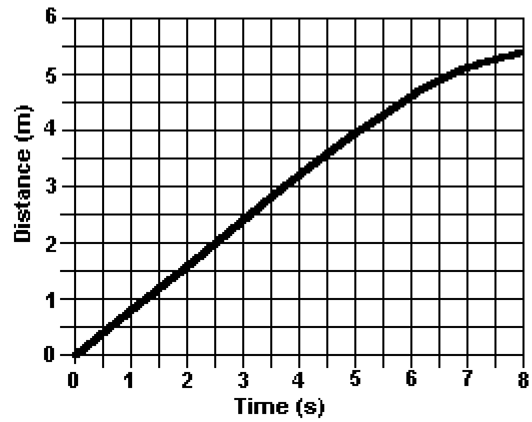
**ATTENTION: All Division I students, START HERE.**
**All Division II students, skip the first ten questions, begin on question 11.**

**THE NEXT TWO QUESTIONS REFER TO THE FOLLOWING GRAPH**




**1.** The graph represents the relationship between distance and time for an object that is moving along a straight line. What is the instantaneous speed of the object at $t$ = 5.0 seconds?

**A)** 0.0 m/s
**B)** 0.8 m/s
**C)** 2.5 m/s
**D)** 4.0 m/s
**E)** 6.8 m/s

**2.** Between what times did the object have a non-zero acceleration?

**A)** 0 s only
**B)** 0 s to 5 s
**C)** 5 s to 8 s
**D)** 0 s to 8 s
**E)** the object was not accelerating at any time

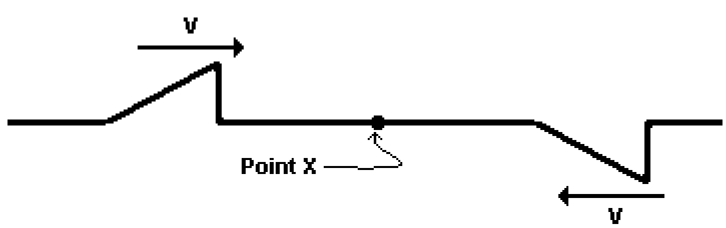
**3.** An airplane takes off and flies 300 miles at an angle of 30$^o$ north of east. It then changes direction and flies 600 miles due west before landing. In what direction is the plane's landing point from its starting point?

**A)** 14.2$^o$ north of west
**B)** 23.8$^o$ north of west
**C)** 37.4$^o$ north of west
**D)** 66.2$^o$ north of west
**E)** 75.9$^o$ north of west

**4.** If a ball is thrown directly upwards with twice the initial speed of another, how much higher will it be at its apex?

**A)** 8 times
**B)** 4 times
**C)** $2\sqrt{2}$ times
**D)** 2 times
**E)** $\sqrt{2}$ times

**5.** The diagram shows two transverse pulses moving along a string. One pulse is moving to the right and the second is moving to the left. Both pulses reach point x at the same instant. What would be the resulting motion of point x as the two pulses pass each other?



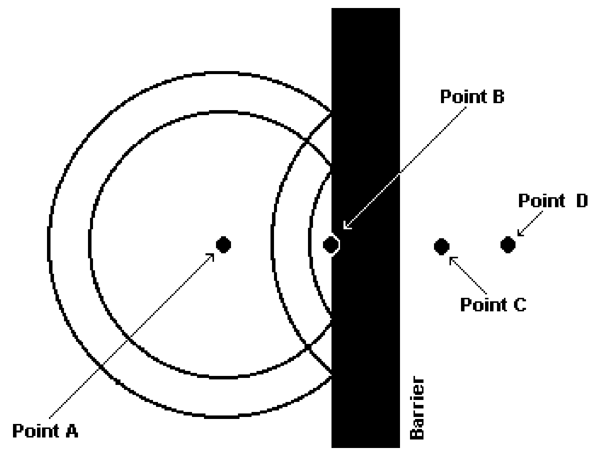

**A)** up then down
**B)** down then up
**C)** up, down, up
**D)** down, up, down
**E)** there would be no motion, the pulses cancel one another

**6.** Three resistors of different values can be connected together in different configurations. If all three resistors are used in a circuit, how many different values of total resistance can be produced?

**A)** 2 **B)** 3 **C)** 5 **D)** 6 **E)** 8

**7.** The diagram shows two water pulses which were originally produced at point A and are beginning to be reflected from a wide barrier as shown. Which of the points in the diagram would represent a virtual source for the reflected waves?

**A)** Point A
**B)** Point B
**C)** Point C
**D)** Point D
**E)** There would be no virtual source for the reflected pulses.




**8.** A gas is enclosed in a cylindrical piston. When the gas is heated from $0^o$ C to $100^o$ C, the piston is allowed to move to maintain a constant pressure. According to the Kinetic-Molecular Theory of Matter

**A)** the mass of the gas will increase
**B)** the number of molecules of gas must increase
**C)** the size of the individual molecules has increased
**D)** the average speed of the molecules has increased
**E)** the molecules continue to strike the sides of the container with the same energy

**9.** When a positive electrically charged glass rod is brought near a neutral hollow metal sphere suspended by an insulating string, the sphere will be attracted to the rod because:

**A)** the rod is much larger than the sphere
**B)** the rod removes electron from the sphere
**C)** the electric charge produces a magnetic field to attract the sphere
**D)** the charge on the rod causes a separation of charge in the sphere
**E)** some of the protons from the rod have been given to the sphere

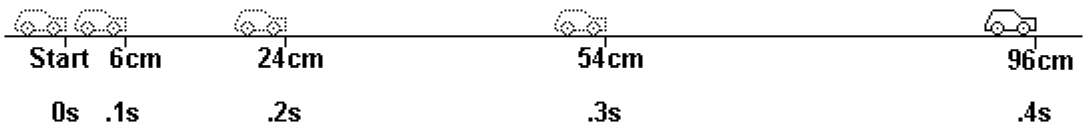
**10.** In Rutherford's famous gold foil scattering experiment, he found that most alpha particles would pass through the foil undeflected. Which of the following nuclear properties can be inferred from this observation?

**A)** The nucleus must have a positive charge
**B)** Most of the mass of an atom is in the nucleus
**C)** The nucleus contains both protons and neutrons
**D)** The diameter of the nucleus is small compared to the diameter of the atom
**E)** None of the above

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

**THE NEXT THREE QUESTIONS REFER TO THE FOLLOWING SCENARIO**

The diagram below represents a toy car starting from rest and uniformly accelerating across the floor. The time and distance traveled from the start are shown in the diagram.




**11.** What was the average speed of the cart between 0.1 seconds and 0.3 seconds?

**A)** 0.6 m/s
**B)** 1.9 m/s
**C)** 2.4 m/s
**D)** 4.8 m/s
**E)** 60 m/s

**12.** What was the acceleration of the cart during the first 0.4 seconds?

**A)** 6.0 m/s/s
**B)** 9.8 m/s/s
**C)** 12 m/s/s
**D)** 25 m/s/s
**E)** 50 m/s/s

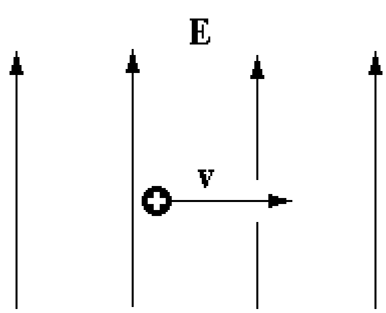
**13.** What was the instantaneous velocity of the cart at 96 centimeters from the start?

**A)** 0.6 m/s
**B)** 1.9 m/s
**C)** 2.4 m/s
**D)** 4.8 m/s
**E)** 60 m/s

**14.** An intrinsic property of matter is one that does not depend on the quantity of matter present. Which of the following properties is NOT an intrinsic property?

**A)** Density **B)** Temperature **C)** Specific Heat **D)** Half-life **E)** Inertia

**15.** A positively charged particle moves to the right. It enters a region of space in which there is an electric field directed up the plane of the paper (see figure). In which direction does a magnetic field have to point in this region so that the particle maintains a constant velocity?



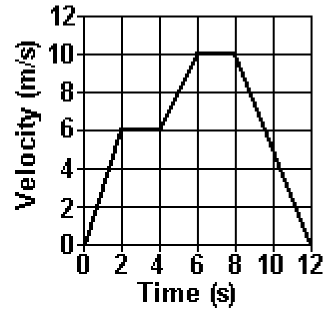

**A)** Into the plane of the page
**B)** Out of the plane of the page
**C)** To the right
**D)** To the left
**E)** Up the plane of the page

**16.** During a particular kind of radioactive decay, a particle is emitted from the nucleus of an atom and the atom's atomic number increases by one. This decay necessarily involves the emission of ______________ from the nucleus?

**A)** an alpha particle
**B)** a beta particle
**C)** a gamma ray
**D)** a proton
**E)** a neutron

**THE NEXT TWO QUESTIONS REFER TO THE FOLLOWING SCENARIO**

The motion of a circus clown on a unicycle moving in a straight line is shown in the graph at the right.



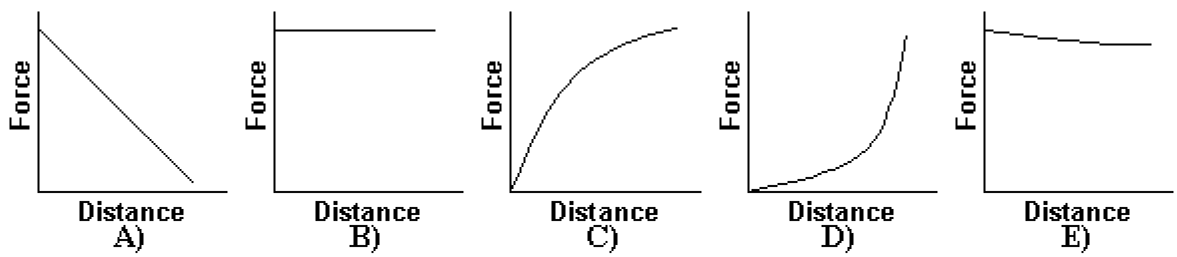

**17.** What would be the acceleration of the clown at 5 s?

**A)** 1.6 m/s$^2$
**B)** 2.0 m/s$^2$
**C)** 3.4 m/s$^2$
**D)** 8.0 m/s$^2$
**E)** none of the above

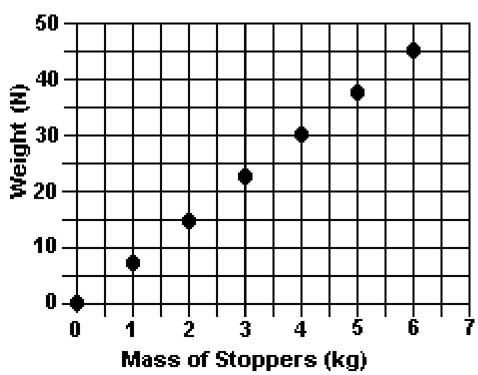
**18.** After 12 seconds, how far is the clown from her original starting point?

**A)** 0 m **B)** 10 m **C)** 34 m **D)** 47 m **E)** 74 m

**19.** As a rocket blasts away from the earth with a cargo for the international space station, which of the following graphs would best represent the gravitational force on the cargo versus distance from the surface of the Earth?



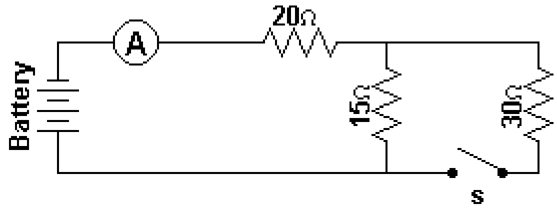

**20.** The graph shows the relationship between the mass of a number of rubber stoppers and their resulting weight on some far-off planet. The slope of the graph is a representation of the:




**A)** mass of a stopper
**B)** density of a stopper
**C)** volume of a stopper
**D)** acceleration due to gravity
**E)** number of stoppers for each unit of weight

**THE NEXT THREE QUESTIONS REFER TO THE FOLLOWING SCENARIO**

An ideal battery, an ideal ammeter, a switch and three resistors are connected as shown. With the switch open as shown in the diagram the ammeter reads 2.0 amperes.




**21.** With the switch open, what would be the potential difference across the 15 ohm resistor?

**A)** 30 V **B)** 40 V **C)** 60 V **D)** 70 V **E)** 110V

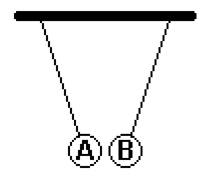
**22.** With the switch open, what must be the voltage supplied by the battery?

**A)** 30 V **B)** 40 V **C)** 60 V **D)** 70 V **E)** 110 V

**23.** When the switch is closed, what would be the current in the circuit?

**A)** 1.1 A **B)** 1.7 A **C)** 2.0 A **D)** 2.3 A **E)** 3.0 A

**24.** Two small hollow metal spheres hung on insulating threads attract one another as shown. It is known that a positively charged rod will attract ball A.




I. Ball A has a positive charge
II. Ball B has a negative charge
III. Ball A and Ball B have opposite charges

Which of the above can be correctly concluded about the charge on the balls?

**A)** I only **B)** II only **C)** III only **D)** all of these **E)** none of these

**25.** If $M$ represents units of mass, $L$ represents units of length, and $T$ represents units of time, the dimensions of power would be:

**A)** $\frac{ML}{T^2}$ **B)** $\frac{ML^2}{T^2}$ **C)** $\frac{ML^2}{T^3}$ **D)** $\frac{ML}{T}$ **E)** $\frac{ML^2}{T}$

**26.** Consider two laboratory carts of different masses but identical kinetic energies and the three following statements.

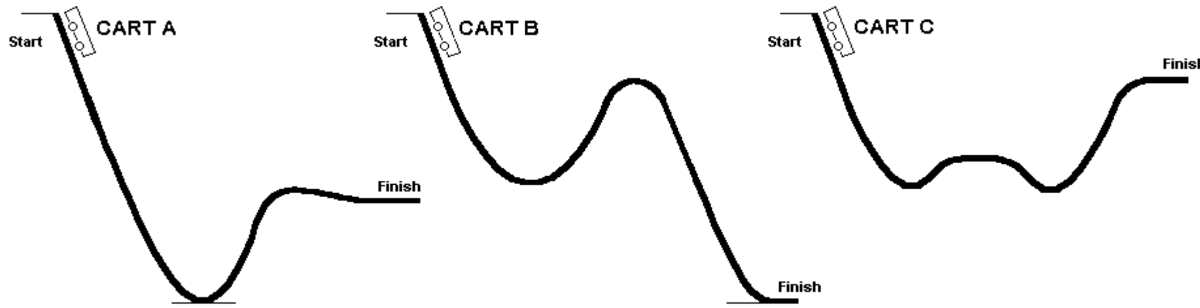
I. The one with the greatest mass has the greatest momentum
II. The same impulse was required to accelerate each cart from rest
III. Both can do the same amount of work as they come to a stop

Which of the above statements would be correct?

**A)** I only
**B)** II only
**C)** III only
**D)** I and II only
**E)** I and III only

**THE NEXT TWO QUESTIONS REFER TO THE FOLLOWING SCENARIO**

The diagram below shows three roller coaster tracks of equal length. Assume that on all tracks the roller coaster carts start from rest at the same elevation and moves frictionlessly over the tracks to the finish.



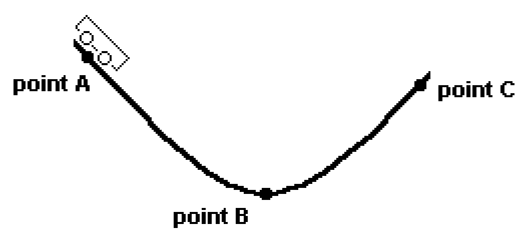

**27.** If all roller coaster carts start at the positions shown, on which track would the roller coaster cart be traveling the fastest at the finish?

**A)** Cart A
**B)** Cart B
**C)** Cart C
**D)** All would reach the finish with the same speed
**E)** More information would be required

**28.** If all roller coaster carts start at the positions shown, on which track would the roller coaster cart reach the finish first?

**A)** Cart A
**B)** Cart B
**C)** Cart C
**D)** All would reach the finish at the same time
**E)** More information would be required

**29.** Assume the roller coaster cart rolls frictionlessly along the curved track from point A to point C under the influence of gravity. What would be the direction of the cart's acceleration at point B?

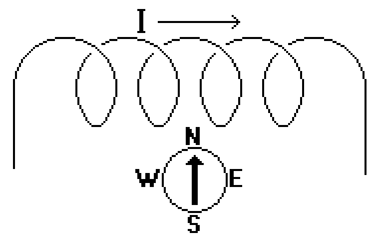



**A)** upward
**B)** downward
**C)** forward
**D)** backward
**E)** no acceleration

**30.** A box falls to the ground from a delivery truck traveling at 30 m/s. After hitting the road, it slides 45 meters to rest. How long does it take the box to come to rest?

**A)** 0.67 s **B)** 1.5 s **C)** 2.0 s **D)** 3.0 s **E)** 6.0 s

**31.** A compass is placed near a coil of wire. A conventional electrical current is then run through the coil from left to right as shown. This will cause the North pole of the compass to:




**A)** point toward the left
**B)** point toward the right
**C)** point toward the bottom of the paper
**D)** not move since the magnetic field of the coil is into the paper
**E)** not move since the magnetic field of the coil is out of the paper

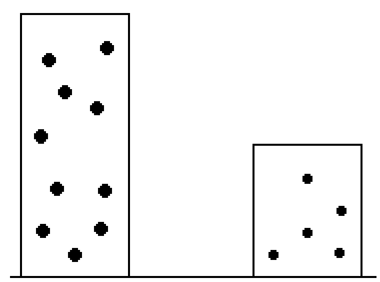
**32.** An automobile engine delivers 24,000 watts (about 32 hp) of power to a car's driving wheels. If the car maintains a constant speed of 30 m/s (about 65 mph), what is the magnitude of the retarding force acting on the car?

**A)** 800 N
**B)** 960 N
**C)** 1950 N
**D)** 720,000 N
**E)** 1,560,000 N

**33.** A short burst of white light strikes a rectangular glass block with an angle of incidence of $0^o$. Which color of transmitted light would be the first to emerge from the opposite side?

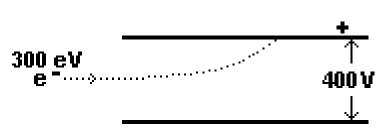
**A)** red
**B)** yellow
**C)** green
**D)** violet
**E)** all colors would emerge at the same instant

**34.** Two containers are filled with gases at the same temperature. In the container on the left is a gas of molar mass *2M,* volume *2V,* and number of moles *2n.* In the container on the right is a gas of molar mass *M,* volume *V,* and moles n. Which is most nearly the ratio of the pressure of the gas on the left to the pressure of the gas on the right?



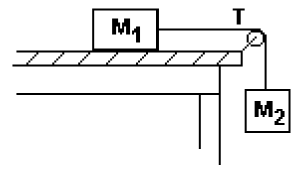
**A)** 1:1
**B)** 2:1
**C)** 4:1
**D)** 8:1
**E)** 16:1

**35.** A 300 eV electron is aimed midway between two parallel metal plates with a potential difference of 400 V. The electron is deflected upwards and strikes the upper plate as shown. What would be the kinetic energy of the electron just before striking the metal plate?




**A)** 360 eV **B)** 400 eV **C)** 500 eV **D)** 700 eV **E)** 740 eV

**36.** Two masses, $m_1$ and $m_2$, are connected by a cord and arranged as shown in the diagram with $m_1$ sliding along on a frictionless surface and $m_2$ hanging from a light frictionless pulley. What would be the mass of the falling mass, $m_2$, if both the sliding mass, $m_1$, and the tension, $T$, in the cord were known?




**A)** $\frac{1}{(g-1)}$

**B)** $\frac{1}{2}Tg$

**C)** $\frac{Tm_1}{(gm_1-T)}$

**D)** $\frac{m_1 g - T}{g}$

**E)** $\frac{m_1(T-g))}{(gm_1-T)}$

**37.** A diffraction grating of 1000 lines/cm has red light of wavelength 700nm pass through it. The distance between the first and third principal bright spots on a screen 2.0m away is

**A)** 14 *cm* **B)** 28 *cm* **C)** 42 *cm* **D)** 140 *cm* **E)** 280 *cm*

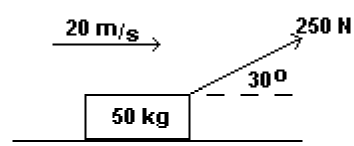
**38.** A $5 \times 10^{-6}$ coulomb electric charge is placed midway between two parallel metal plates connected to a 9-volt battery. If the electric charge experiences a force of $1.5 \times 10^{-4}$ newtons, what is the separation of the metal plates?

**A)** $6.75 \times 10^{-9}$m **B)** $2.7 \times 10^{-4}$m **C)** $3.7 \times 10^{-3}$m **D)** 0.30 m **E)** 3.3 m

**39.** A parallel-plate capacitor is connected to a resistanceless circuit with a battery having emf î until the capacitor is fully charged. The battery is then disconnected from the circuit and the plates of the capacitor are moved to half of their original separation using insulated gloves. Let $V_{new}$ be the potential difference across the capacitor plates when the plates are moved together. Let $V_{old}$ be the potential difference across the capacitor plates when connected to the battery. $\frac{V_{new}}{V_{old}} =$

**A)** $\frac{1}{4}$ **B)** $\frac{1}{2}$ **C)** 1 **D)** 2 **E)** 4

**40.** A box with a mass of 50 kg is dragged across the floor by a rope which makes an angle of $30^o$ with the horizontal. Which of the following would be closest to the coefficient of kinetic friction between the box and the floor if a 250 newton force on the rope is required to move the crate at a constant speed of 20 m/s as shown in the diagram?



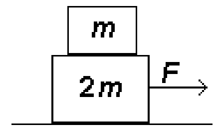

**A)** 0.26 **B)** 0.33 **C)** 0.44 **D)** 0.59 **E)** 0.77

**<u>ATTENTION</u>: All Division I students, <u>STOP</u>.**
**All Division II students, turn page and continue to question 50.**

**41.** A person throws a small object from the top of a building at an angle of $30^0$ above the horizontal. At the instant that the object returns to the same height from which it was thrown, at what rate is the speed of the object changing? Ignore air resistance and let g be the acceleration due to gravity.

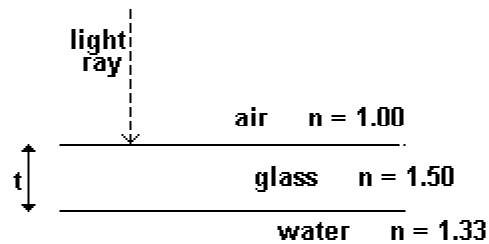
**A)** 0 **B)** $g \tan 30^o$ **C)** $g \sin 30^o$ **D)** $g \cos 30^o$ **E)** $g$

**42.** A small box of mass *m* is placed on top of a larger box of mass *2m* as shown in the diagram at right. When a force *F* is applied to the large box, both boxes accelerate to the right with the same acceleration. If the coefficient of friction between all surfaces is ì, what would be the force accelerating the smaller mass?




**A)** $\frac{F}{3} - mgm$ **B)** $F - 3mgm$ **C)** $F - mgm$ **D)** $\frac{F - mgm}{3}$ **E)** $\frac{F}{3}$

**43.** A light ray is incident normal to a thin layer of glass. Given the figure, what is the minimum thickness of the glass that gives the reflected light an orangish color ( ë$_{air}$ = 600 nm) ?

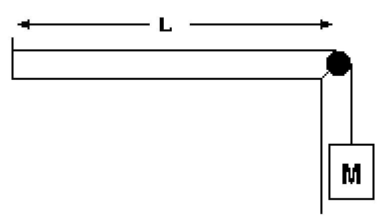



**A)** 50 *nm*
**B)** 100 *nm*
**C)** 150 *nm*
**D)** 200 *nm*
**E)** 500 *nm*

**44.** A thermally insulating container has a membrane separating the container into two equal parts. In one part is a vacuum. In the other part is an ideal gas of temperature *T* and internal energy *U*. The membrane is punctured and the gas rushes into the region which was vacuum. After the system has returned to equilibrium, which of the following is **NOT** true for the gas?

**A)** The temperature of the gas is unchanged.
**B)** No work is done by the gas on the surroundings.
**C)** There is no heat exchanged by the gas with the surroundings.
**D)** There is no entropy change of the system.
**E)** The internal energy of the gas is unchanged.

**45.** A light inextensible string is connected to a mass, *M*, that provides the tension in the string. A length *L* of the string has a fundamental frequency of vibration of $f_M$. If a second identical mass is now connected to the original mass, the new fundamental frequency of the string ($f_{2M}$) of string length *L* in comparison to the fundamental frequency with only one mass connected $f_M$ is




**A)** $f_{2M} = 2 f_M$
**B)** $f_{2M} = \sqrt{2} f_M$
**C)** $f_{2M} = f_M$
**D)** $f_{2M} = \frac{1}{2} f_M$
**E)** $f_{2M} = \frac{1}{\sqrt{2}} f_M$

**46.** A hotplate is designed such that it has a resistance of 12 Ù when operating at 120 volts. What is the minimum amount of time that it would take to warm 0.45 kg of water from 15$^{o}$C to 85$^{o}$C?

**A)** 20 s  **B)** 26 s  **C)** 110 s  **D)** 180 s  **E)** 220 s

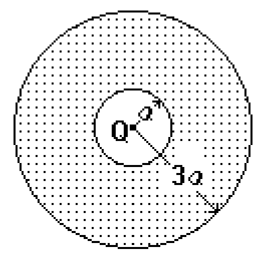
**47.** A car heads toward a brick wall in a crash test at 30 m/s. The horn is emitting a sound with frequency 250 *Hz* as it approaches the wall. If the air is still and the speed of sound in air is 340 m/s, what beat frequency from the horn would the driver of the car detect?

**A)** 0 *Hz*  **B)** 22 *Hz*  **C)** 24 *Hz*  **D)** 41 *Hz*  **E)** 48 *Hz*

**48.** An object of mass *M* is dropped from a height *H* above the ground. The object crashes into some soft earth and comes to rest by compressing the earth a distance of *H*/2. Assuming that air resistance is negligible, what is the magnitude of the average constant force exerted by the ground on the object while coming to rest?

**A)** 0  **B)** $\frac{2}{3}Mg$  **C)** $Mg$  **D)** $2Mg$  **E)** $3Mg$

**49.** A solid, uncharged conducting sphere of radius 3*a* contains a hollowed spherical region of radius *a*. A point charge +Q is placed at the common center of the spheres. Taking V = 0 as $r \to \infty$, the potential at position $r = 2a$ from the center of the spheres is:

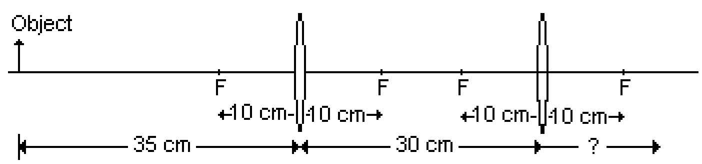



**A)** 0  **D)** $\frac{2kQ}{3a}$

**B)** $\frac{kQ}{3a}$  **E)** $\frac{kQ}{a}$

**C)** $\frac{kQ}{2a}$ 40

**50.** Two thin lenses each with a focal length of +10 cm are located 30 cm apart with their optical axes aligned as shown. An object is placed 35 cm from the first lens. After the light has passed through both lenses, at what distance from the second lens will the final image be formed?




**A)** 65 cm  **B)** 35 cm  **C)** 27 cm  **D)** 17 cm  **E)** -14 cm

**<u>ATTENTION</u>: All Division II students STOP. All Division II answers should appear in Numbers 11-50 on your answer sheet. Numbers 1-10 on you answer sheet should remain blank.**

**<u>2002 PhysicsBowl Answer Sheet</u>**

| Question | Answer |
|---|---|
| 1 | B |
| 2 | C |
| 3 | B |
| 4 | B |
| 5 | C |
| 6 | E |
| 7 | C |
| 8 | D |
| 9 | D |
| 10 | D |
| 11 | C |
| 12 | C |
| 13 | D |
| 14 | E |
| 15 | B |
| 16 | B |
| 17 | B |
| 18 | E |
| 19 | E |
| 20 | D |
| 21 | A |
| 22 | D |
| 23 | D |
| 24 | E |
| 25 | C |

| Question | Answer |
|---|---|
| 26 | E |
| 27 | B |
| 28 | A |
| 29 | A |
| 30 | D |
| 31 | A |
| 32 | A |
| 33 | A |
| 34 | A |
| 35 | C |
| 36 | C |
| 37 | B |
| 38 | D |
| 39 | B |
| 40 | D |
| 41 | C |
| 42 | A |
| 43 | B |
| 44 | D |
| 45 | B |
| 46 | C |
| 47 | E |
| 48 | E |
| 49 | B |
| 50 | C |