O.A.P.T. Physics Contest

May 1, 2001 **Time: 1.0 hour**

The Ontario Association of Physics teachers is affiliated with The American Association of Physics Teachers

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Contest Committee: Terry Price (convenor), Rolly Meisel(author), Vida Ghaem-Maghami(author), Douglas Abe (past author)

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Submitted questions: Committee and John Beattie, John Colterman, Kris Barron, Gabriela Smeianu, John Childs

Physics Departments at the following universities have shown interest in your physics education and have generously contributed funds for prizes given to the provincial winners:

McMaster University (Faculty of Engineering Fireball Show)
Queen¹s University (Department of Physics Stirling Hall)
Ryerson Polytechnic University (Department of Math/Physics/Computer Sc)
University of Toronto, Scarborough Campus (Division of Physical Sciences)
University of Toronto, St. George Campus (Department of Physics)
University of Toronto (Department of Physics)
University of Western Ontario (Department of Physics & Astronomy)
University of Windsor (Department of Physics) **Wilfrid Laurier University** (Department of Physics)
Laurentian University (Department of Physics) **University of Waterloo** (Department of Physics)
University of Guelph (Department of Physics) **Trent University** (Department of Physics)

The following companies have graciously contributed to the prize awards:

AECL CCS Educational Inc. Texas Instruments Paramount Canada¹s Wonderland Vernier Software

PRIZES The two students having the highest score in each school will be recognized by the OAPT with certificates. The top students in the province will receive a cash prize and/or a calculator with a special certificate from OAPT.

INSTRUCTIONS

1. *For each question select the <u>best</u> answer from the choices offered.*
2. *When you have finished, carefully transfer your answers to the computer answer sheet as instructed by your teacher.*
3. *Solutions are not required.*
4. *Calculators may be used, but no other aids are allowed.*

All questions are of equal value and there are no marks deducted for incorrect answers

DATA: Acceleration due to gravity = **9.80 m/s^2**

1) While you are working on this physics contest, you are being whisked along with the Earth on its journey around the Sun, which is about 1.50 x 10^8 km away. At approximately what speed does the Earth carry you along?

A) 29.9 km/s B) 4.76 km/s C) 1720 km/s D) 1670 km/s E) 1.09x10^4 km/s

2) A pilot has an airplane that flies at 200 km/h in still air. She decided to fly 200 km north to air drop a birthday card for a friend, and then return home. There was a steady wind blowing from the north at 50 km/h. Assuming that the time to drop the package and turn the plane to be negligible, the total round trip time for the flight would be:

A) 1.6 h B) 2.0 h C) 2.1 h D) 2.5 h E) 2.7 h

3) If a dragster goes from rest at the starting line to the finish line 2/10 of a kilometer away in 10 seconds, what is its speed at the finish line, assuming constant acceleration?

A) 2 km/h B) 72 km/h C) 100 km/h D) 120 km/h E) 144 km/h

4) Anne Montminy, our double medal winner at the Olympics last September, did a triple somersault off the 10 m tower. She left the tower with a speed of 4 m/s and entered the water in the vertical position. What was her acceleration just before she hit the water?

A) the acceleration due to gravity, "g" B) slightly more than the acceleration due to gravity
C) slightly less than the acceleration due to gravity D) zero
E) cannot be determined unless the direction of her velocity is given

5) A man was walking westwards down the aisle of a train moving west at 120 km/h when he felt "thrown" to his left. The train:

A) turned southwards B) turned northwards C) slowed down D) sped up E) accelerated eastwards

6) Patty was riding in her brother Chuck's car at a city speed of 15.0 m/s. Patty thought that the speed was fairly slow, so she did not bother wearing a seatbelt. She figured that she could use her arms to exert a stopping force before she hit the dashboard 0.75 m away. Chuck's attention was diverted and he didn't notice the large garbage truck pull out in front of him. The ensuing collision brought his car to rest in a negligible time and distance. Assuming a constant deceleration, what average force would Patty need to stop her 70.0 kg body before she hit the dashboard?

A) 70.0 N B) 788 N C) 1050 N D) 1400 N E) 10,500 N

7) While driving down an icy road in his pickup truck, Dan slid off the road into a ditch. He and his two friends each exerted a force of 200 N on the truck for two minutes, but failed to move it. The work done by the three friends on the truck was:

A) 0 J B) 600 J C) 24,000 J D) 72,000 J E) Cannot be determined from the information given.

8) Suppose you are pushing on a loaded shopping cart. Which of the following is true?

A) If action force always equals reaction force, you cannot move the cart because the cart pushes you backward just as hard as you push forward on the cart.
B) You push the cart slightly harder than the cart pushes you backward, so the cart moves forward
C) You push before the cart has time to react, so the cart moves forward.
D) You can push the cart forward only if you weigh more than the cart.
E) You are in contact with the earth through your high-friction shoes, while the cart is free to roll on its round wheels, so the cart moves.

9) Toyota and Honda have both started selling hybrid gas and electric cars. Some of the energy for the batteries which powers the electric motor is obtained from:

A) A fuel cell B) Plugging the car into an electrical outlet at night C) Solar cells
D) Energy transfer as the brakes slow the car E) All of these

10) The purpose of a lightning rod on a building is to:

A) attract lightning to itself B) repel lightning from the building C) insulate the building from a flow of electrons due to lightning strike D) provide a safe path to ground for lightning E) A, C and D

11) Annika painted three ping-pong balls with graphite and suspended them from the ceiling with insulation string. She placed a charge of 12 microcoulombs on ball A. It swung over, touched ball B and then detached. Ball B swung over and touched ball C and detached. The final charges on the balls A, B and C respectively, in microcoulombs, were:

A) 4, 4, 4 B) 2, 4, 8 C) 6, 3, 3 D) 3, 6, 3 E) 3, 3, 6

12) The battery in Siddiq's car is rated at 12.0 volts and 60.0 ampere-hours. The car has a mass of 6.00x10^2 kg. If the energy in the battery were used to lift the car straight up, approximately how high would it go?

A) 12.0 cm B) 1.20 m C) 432 km D) 440 m E) 4320 m

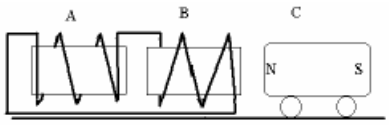
13) Dan's family moved to the tiny banana republic of Costa Livin, taking their 120 V appliances with them. When they found that the local outlets carried a potential of 240 V, Dan figured there was no problem. He wired pairs of appliances in series, such as a 10 Ω toaster and a 15 Ω iron. When he plugged them in

A) both appliances would operate normally B) neither appliance would work at all
C) the toaster would overheat and the iron would run colder than normal
D) the iron would overheat and the toaster would run colder than normal
E) the 15 A fuse protecting the circuit would blow immediately

14) A magnetic compass was pointing in its normal north-south direction. A wire was placed below it, and a current was sent through the wire. The compass needle did not move, even when tapped slightly. The wire was ___ to the compass, and the electron current in the wire was flowing ___.
A) parallel, north B) parallel, south C) perpendicular, west D) perpendicular, east
E) cannot be determined from this information

15) While vacationing in Quito, Ecuador, which is right on the equator, a positively charged cosmic ray from the sun came hurtling down through the atmosphere right at you. As it interacted with the Earth's magnetic field, it would be deflected:
A) northwards B) southwards C) eastwards D) westwards E) not at all

16) Two coils marked **A** and **B**, wrapped around empty cardboard tubes, were wired together as shown in the diagram. A magnet on wheels marked **C** was placed near the end of coil **B**. If the ___ pole of a permanent magnet were ___ coil **A** from the left**,** then magnet **C** would move to the right.

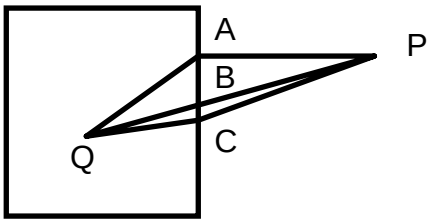


A) north, plunged into B) north, pulled out of C) south, plunged into D) south, pulled out of E) either (A) or (D) would work

17) An appliance in your home that would not be expected to contain an electromagnet is:

A) a refrigerator B) a television C) a toaster D) a washing machine E) a vacuum cleaner

18) A lifeguard at P on the beach must rescue a drowning person in the water at Q. Assuming that she can run faster than she can swim, which path will take the least time?



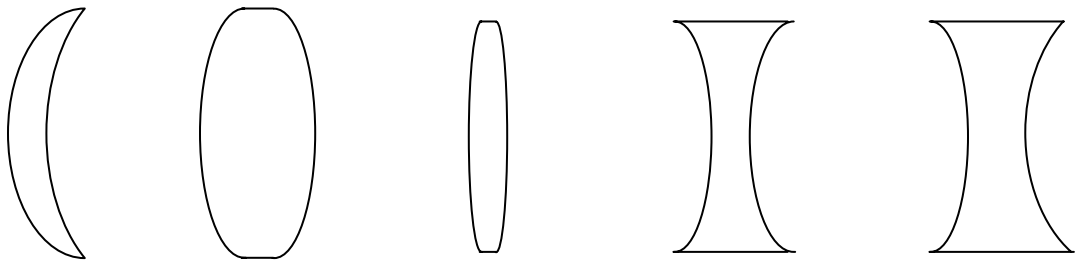
A) P to A to Q B) P to B to Q C) P to A to C to Q
D) P to C to Q E) All these paths take the same time

19) What must be the minimum length of a vertical plane mirror in order for you to see a full view of yourself?

A) ¼ your height B) ½ your height C) ¾ your height D) your full height
E) The answer depends on your distance from the mirror.

20) Several lenses with the same diameter are shown below. Which of these lenses would bring a beam of light to a spot closest to the lens?

A) B) C) D) E)



21) Suppose that Albert Michelson set up his octogonal rotating mirror to measure the speed of light. Suppose further that he used a reflecting mirror 36.0 km away. What is the minimum number of revolutions per second required of the rotating mirror?
A) 8330 B) 4168 C) 1040 D) 521 E) 260

22) Which of the following phenomena is not considered as an interference effect?

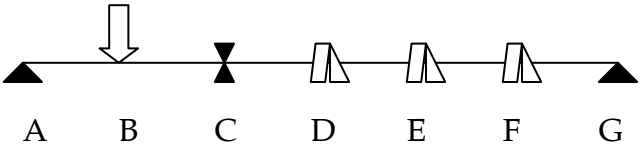
A) air column resonance B) the Doppler effect C) beats
D) standing waves in a string E) all the above are interference effects

23) Radio station CDB broadcasts at a frequency of 102.1 MHz and uses a quarter wave antenna. The height of antenna required is approximately:
A) 75 cm B) 150 cm C) 300 cm D) 102.1 m E) 102.1 km

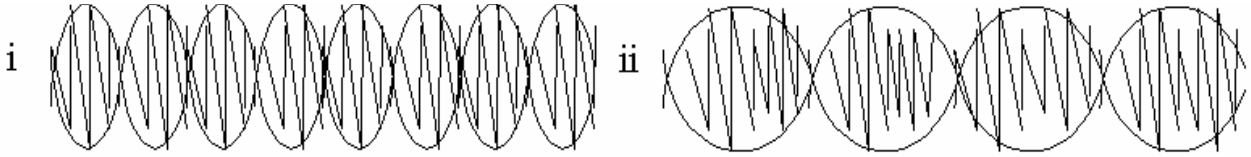
24) A large pendulum was constructed at the south pole, and set vibrating. Six hours later the plane of vibration will have rotated through an angle of:
A) 0^o B) 90^o C) 180^o D) 270^o E) 360^o

25) A guitar string is stretched as shown from point A to G. Equal intervals are marked off by B, C, D, E and F. Paper folders are placed in locations D, E and F. The string is pinched at C and twanged at B. What happens?

A) All of the riders will jump off
B) None of the riders will jump off
C) The rider at E jumps off
D) The riders at D and F jump off
E) The riders at E and F jump off



26) Two different notes are sounded at the same time. The sound waves for the two notes are added and the sum is shown in display (i). Then a different pair of notes is sounded and their sum is shown in display (ii). Which pair of notes is closer in frequency?



A) display (i) B) Notes shown in display (i) are as close in frequency as display (ii) C) display (ii)
D) display (i) is identical to display (ii) E) It is not possible from the displays to tell which pair of notes is closer in frequency

27) Some isotopes are unstable because they have too few neutrons compared to the number of protons in the nucleus. A proton then decays into a neutron, a positron and a neutrino. The positron is a particle of antimatter that is much like an electron, except that it carries a positive charge. One element that decays by positron emission is neon-19. Given that neon has an atomic number of 10, the product nucleus would have an atomic number of ___ and an atomic mass of ___.
A) 9, 19 B) 10, 18 C) 11, 19 D) 11, 18 E) 9, 18

28) Carbon dating is useful for estimating the age of fossils of organisms that were once alive. The ratio of radioactive C-14 to ordinary C-12 in living organisms is about $1:10^{12}$. However, once an organism dies, the C-14 decays. By measuring the ratio of C-14 to C-12 in the fossil, and knowing that C-14 has a half-life of 5700 years, an estimate for the age of the fossil may be made. If a fossil is found with a C-14 to C-12 ratio of $1.25:10^{13}$, approximately how old is the fossil?
A) 5700 years B) 11,400 years C) 17,100 years D) 34,200 years E) 45,600 years

29) Superconductivity has been a hot topic in physics over the last few years. Some conductors seem to lose all of their resistance to a flow of electrons when cooled below a certain temperature, called the superconducting transition temperature. Although most people only heard of it a few years ago, it was actually discovered by Heike Kamerlingh Onnes in
A) the 1980's B) the 1950's C) the 1930's D) the 1910's E) the 1800's

30) Half of the 2000 Nobel Prize in physics was awarded to Jack S. Kilby for his pioneering work in semiconductor technology which led to the development of integrated circuits, making it possible to pack thousands of devices onto a single silicon "chip". Since the first ICs, development seems to have followed Moore's Law, which predicts that the number of components will double every eighteen months. For every component on a chip in 1960, about how many components would we expect to find in the year 2000?
A) 27 B) 40 C) 10^8 D) 10^{27} E) 10^{40}