

PHYSICS BOWL - APRIL 21, 1999

40 QUESTIONS—45 MINUTES

This contest is sponsored by the **American Association of Physics Teachers (AAPT)** and **Metrologic Instruments** to generate interest in physics and to recognize outstanding high school physics students and their teachers.

This competition is held in 15 regions, each with two divisions. Division I is for students in a first-year physics course; Division II is for students in a second-year physics course. A school's score in a division is the sum of the four highest student scores in that division. To compete in a division, a school must have at least four students participating. A school may compete in either or both divisions, provided that it has at least four eligible students participating in each division.

The ten highest scoring students in the country will receive \$1000 scholarships. Thirty highest scoring student in each division will receive \$300 each. Also thirty next highest scoring students in each division will receive \$100 each. All participating students will be recognized with a certificate from AAPT and Metrologic Instruments.

Note: one award per student

If your exam is a photocopy or previously opened, your school is in violation of US copyright law and the contest rules.

INSTRUCTIONS

Answer sheet: Write and bubble-in the appropriate information on your answer sheet. You should fill in your name, sex, grade, ID Number and 3 special codes. In the block labeled "IDENTIFICATION NUMBER," write in and encode the nine-digit identification number your teacher gives you. You will also need to fill in two special codes to identify the region you are from and which level of physics you are taking. Your answer sheet will be machine graded. Be sure to use a #2 pencil, fill the bubbles completely, and make no stray marks on the answer sheet. You will use only the first 40 answer blocks on the sheet.

Calculator: A hand-held calculator may be used. However, any memory must be cleared of data and programs. Calculators may not be shared.

Formulas and constants: The formulas and constants provided with these instructions may be used.

Time limit: 45 minutes.

Score: Your score is equal to the number of correct answers (no deduction for incorrect answers). If there are tie scores, the entries will be compared, from the end of the test forward, until the tie is resolved. Thus, the answers to the last few questions may be important in determining the winner, and you should consider them carefully.

Good Luck!

Do Not Open This Booklet Until You Are Told to Begin.

Copyright © 1999, AAPT

INSTRUCTIONS: Please check to see that your name, sex, grade, IDENTIFICATION NUMBER and SPECIAL CODES are all properly filled out and bubbled-in on your answer sheet before you begin. For each question below, select the response which represents the best answer and bubble-in the appropriate space on your answer sheet.

1. The change of distance per unit time without reference to a particular direction is called

- [A] inertia [B] speed [C] velocity [D] acceleration [E] position

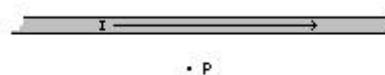
2. Which of the following terms is **NOT** related conceptually to the others?

- [A] vector [B] resultant [C] component [D] exponent [E] equilibrant

3. If the net force on an object were doubled while at the same time the mass of the object was halved, then the acceleration of the object is

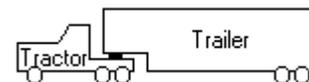
- [A] 1/4 as great.
[B] 1/2 as great.
[C] 2 times greater.
[D] 4 times greater.
[E] unchanged.

4. If conventional (positive) electric current flows from left to right in a wire as shown in the diagram, what is the direction of the magnetic field at point P?



- [A] toward top of paper
[B] towards bottom of paper
[C] into paper
[D] out of paper
[E] to the right

5. A tractor-trailer truck is traveling down the road. The mass of the trailer is 4 times the mass of the tractor. If the tractor accelerates forward, the force that the trailer applies on the tractor is



- [A] 4 times greater than the force of the tractor on the trailer.
[B] 2 times greater than the force of the tractor on the trailer.
[C] equal to the force of the tractor on the trailer.
[D] 1/4 the force of the tractor on the trailer.
[E] zero since the tractor is pulling the trailer forward.

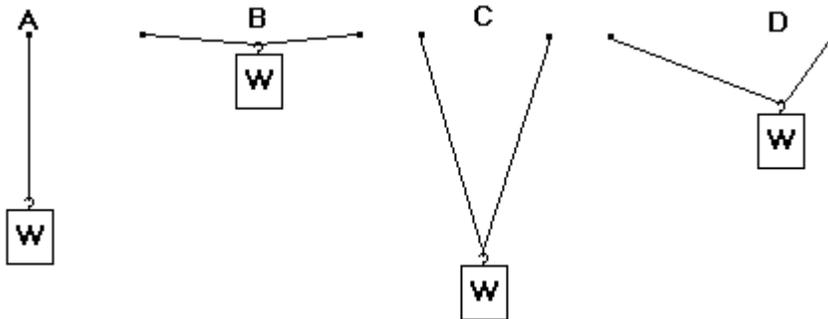
6. An airplane with air speed 120 km/h is heading due north in a wind blowing due east at 50 km/h. What is the ground speed of the plane?

- [A] 60 km/h [B] 120 km/h [C] 130 km/h [D] 140 km/h [E] None of these

7. In the absence of air resistance, if an object were to fall freely near the surface of the Moon,

- [A] its velocity could never exceed 10 m/s.
[B] its acceleration would gradually decrease until the object moves with a terminal velocity.
[C] the acceleration is constant.
[D] it will fall with a constant speed.
[E] the acceleration is zero.

8. A weight can be hung in any of the following four ways. In which case is the string most likely to break?



- [A] A [B] B [C] C [D] D [E] all the same

9. If air resistance can be neglected, what happens to the horizontal velocity component of a basketball as it is thrown to the basket from the free-throw line?

- [A] increases
[B] decreases
[C] decreases until the ball reaches the top then increases as the ball comes down
[D] increases until the ball reaches the top then decreases as the ball comes down
[E] remains constant

10. A simple machine can **NOT** do which of the following:

- [A] have a mechanical advantage greater than 1.
[B] change the direction of the force.
[C] move the resistance a greater distance than the applied force.
[D] increase the energy put into it.
[E] produce a force on the resistance which is greater than the applied force.

11. Assume that the Earth attracts John Glenn with a gravitational force F at the surface of the Earth. When he made his famous second flight in orbit, the gravitational force on John Glenn while he was in orbit was closest to which of the following?

- [A] $0.95F$ [B] $0.50F$ [C] $0.25F$ [D] $0.10F$ [E] zero

12. Two boxes are accelerated to the right on a frictionless horizontal surface as shown. The larger box has a mass of 9 kilograms and the smaller box has a mass of 3 kilograms. If a 24 newton horizontal force pulls on the larger box, with what force does the larger box pull on the smaller box?



- [A] 3 N [B] 6 N [C] 8 N [D] 18 N [E] 24 N

13. A heating coil is rated 1200 watts and 120 volts. What is the maximum value of the current under these conditions?

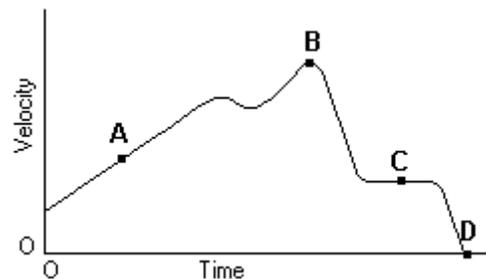
- [A] 10.0 A [B] 12.0 A [C] 14.1 A [D] 0.100 A [E] 0.141 A

14. A construction laborer holds a 20 kilogram sheet of wallboard 3 meters above the floor for 4 seconds. During these 4 seconds how much power was expended on the wallboard?

- [A] 2400 watts [B] 320 watts [C] 27 watts [D] 15 watts [E] none of these

15. Given the graph of the velocity vs. time of a duck flying due south for the winter. At what point did the duck stop its forward motion?

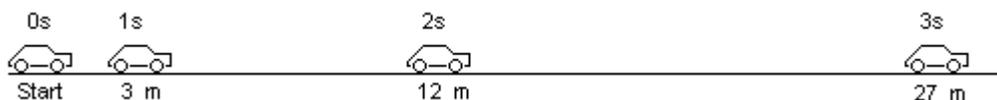
- [A] A
[B] B
[C] C
[D] D
[E] none of these points



16. Which of the following principles best explains why large tractor-trailer trucks generally accelerate much more slowly than automobiles?

- [A] To every action there is an equal reaction.
[B] Every body attracts every other body in the universe.
[C] A force is necessary to change the speed or direction of a body.
[D] The total momentum of interacting bodies is always conserved.
[E] The acceleration of a body is inversely proportional to its mass and directly proportional to the external force acting on the body.

The next 2 questions refer to the diagram below which shows the position and elapsed time of a car starting from rest and uniformly accelerating in a straight line.



17. What was the average velocity of the car during the third second?

- [A] 15 m/s [B] 12 m/s [C] 9 m/s [D] 5 m/s [E] 2 m/s

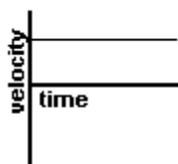
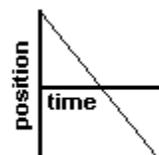
18. The average acceleration during the entire 3 second interval is closest to

- [A] 27 m/s² [B] 9 m/s² [C] 6 m/s² [D] 5 m/s² [E] 3 m/s²

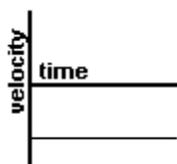
19. A 50 kilogram skater at rest on a frictionless rink throws a 2 kilogram ball, giving the ball a velocity of 10.0 m/s. Which statement describes the skater's subsequent motion?

- [A] 0.4 m/s in the same direction as the ball.
 [B] 0.4 m/s in the opposite direction to the ball.
 [C] 2 m/s in the same direction as the ball.
 [D] 4 m/s in the same direction as the ball.
 [E] 4 m/s in the opposite direction to the ball

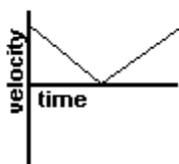
20. What is the shape of the velocity time graph for an object with the position time graph shown in the diagram at right?



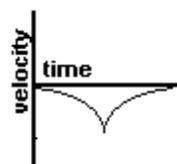
[A]



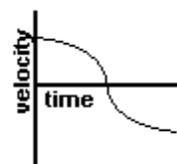
[B]



[C]



[D]



[E]

21. What happens to the force of gravitational attraction between two small objects if the mass of each object is doubled and the distance between their centers is doubled?

- [A] It is doubled
 [B] It is quadrupled
 [C] It is halved
 [D] It is reduced fourfold
 [E] It remains the same

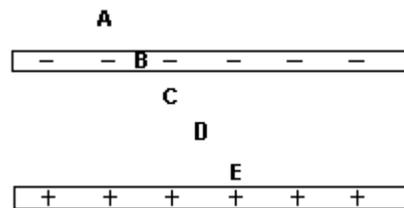
22. A child whirls a ball at the end of a rope, in a uniform circular motion. Which of the following statements is **NOT** true?

- [A] The speed of the ball is constant
- [B] The velocity of the ball is constant
- [C] The radius is constant
- [D] The magnitude of the ball's acceleration is constant
- [E] The acceleration of the ball is directed radially inwards towards the center

23. What is the resistance of a 60 watt light bulb designed to operate at 120 volts?

- [A] .5 Ω
- [B] 2 Ω
- [C] 60 Ω
- [D] 240 Ω
- [E] 7200 Ω

24. Consider the two oppositely charged plates as shown in the diagram. At which of the marked points shown in the diagram would a positively charged particle have the greatest electrical potential energy?

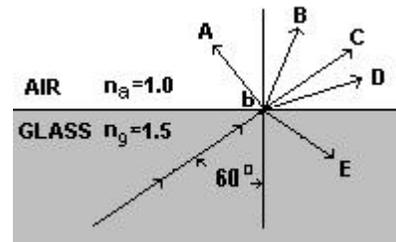


- [A] A
- [B] B
- [C] C
- [D] D
- [E] E

25. Pioneering radio station KFKA started broadcasting 78 years ago at 1310 (1.31 MHz) on the AM dial. What is the approximate length of its radio waves?

- [A] 23 m
- [B] 230 m
- [C] 2300 m
- [D] 23,000 m
- [E] 3×10^8 m

26. A beam of light traveling in glass ($n_g=1.5$) strikes a boundary with air ($n_a=1.0$) at point P. The angle of incidence is 60° as shown in the diagram. Which ray would best indicate the beam's path after point P?

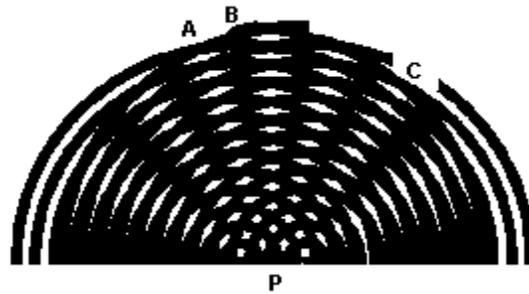


- [A] A
- [B] B
- [C] C
- [D] D
- [E] E

27. Assume that waves are propagating in a uniform medium. If the frequency of the wave source doubles then

- [A] the speed of the waves doubles
- [B] the wavelength of the waves doubles
- [C] the speed of the waves halves
- [D] the wavelength of the waves halves
- [E] none of the above

28. In the diagram, which of the following would represent a zone or zones of constructive interference?



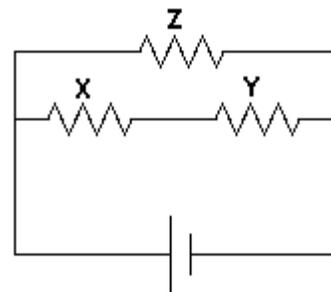
- 1) from P to A 2) from P to B 3) from P to C

- [A] only zone number 1
- [B] only zone number 2
- [C] only zone number 3
- [D] only zones numbered 1 and 2
- [E] only zones numbered 1 and 3

29. Two light wires are hung vertically. With electrical current in both wires directed upwards

- [A] the wires will experience a force of attraction
- [B] the wires will experience a force of repulsion
- [C] the force on the right hand wire will cancel the force on the left hand wire
- [D] both wires will experience a torque until they are at right angles to one another
- [E] none of the above

30. Given the simple electrical circuit at the right. If the current in all three resistors is equal, which of the following statements must be true?

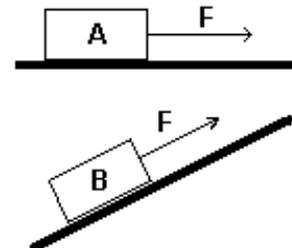


- [A] X, Y, and Z all have equal resistance
- [B] X and Y have equal resistance
- [C] X and Y added together have the same resistance as Z
- [D] X and Y each have more resistance than Z
- [E] none of the above must be true

31. Wire Y is made of the same material but has twice the diameter and half the length of wire X. If wire X has a resistance of R then wire Y would have a resistance of

- [A] $R/8$ [B] $R/2$ [C] R [D] $2R$ [E] $8R$

32. A wooden box is first pulled across a horizontal steel plate as shown in the diagram A. The box is then pulled across the same steel plate while the plate is inclined as shown in diagram B. How does the force required to overcome friction in the inclined case (B) compare to the horizontal case (A)?



- [A] the frictional force is the same in both cases
- [B] the inclined case has a greater frictional force
- [C] the inclined case has less frictional force
- [D] the frictional force increases with angle until the angle is 90° , then drops to zero
- [E] more information is required

33. One object at the surface of the Moon experiences the same gravitational force as a second object at the surface of the Earth. Which of the following would be a reasonable conclusion?

- [A] both objects would fall at the same acceleration
- [B] the object on the Moon has the greater mass
- [C] the object on the Earth has the greater mass
- [D] both objects have identical masses
- [E] the object on Earth has a greater mass but the Earth has a greater rate of rotation.

34. A small light bulb is placed 20 cm to the right of a converging lens of focal length 10 cm. Which of the following statements is **NOT** true about the image of the bulb formed by the lens?

- [A] It is virtual
- [B] It is inverted
- [C] It is the same size as the bulb
- [D] It is 20 cm to the left of the lens
- [E] It can be projected on a screen

35. The following equation is an example of what kind of nuclear reaction?

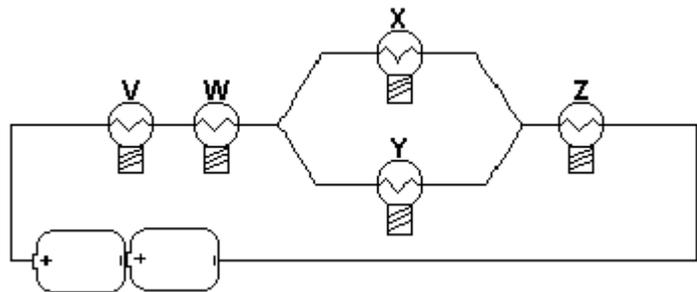


- [A] fission
- [B] fusion
- [C] alpha decay
- [D] beta decay
- [E] positron decay

36. What happens to the inertia of an object when its velocity is doubled?

- [A] the object's inertia becomes $\sqrt{2}$ times greater
- [B] the object's inertia becomes 2 times greater
- [C] the object's inertia becomes 4 times greater
- [D] the object's inertia becomes 8 times greater
- [E] the object's inertia is unchanged

37. The diagram at right represents a simple electric circuit composed of 5 identical light bulbs and 2 flashlight cells. Which bulb (or bulbs) would you expect to be the brightest?



- [A] V only
- [B] V and W only
- [C] V and Z only
- [D] V, W and Z only
- [E] all five bulbs are the same brightness

38. An image is formed on a screen by a convergent lens. If the top half of the lens is then covered what will happen to the image?

- [A] the image is dimmer but otherwise unchanged
- [B] the image becomes half as big
- [C] only the top half of the image is produced
- [D] only the bottom half of the image is produced
- [E] the image becomes half as big and is inverted from its original position.

39. The driver of an automobile must carefully control each of the following devices. Which of these devices can cause an acceleration in a moving car?

- 1) the break pedal 2) the gas pedal 3) the steering wheel

- [A] only number 1
- [B] only number 2
- [C] only number 3
- [D] only numbers 1 and 2
- [E] numbers 1, 2, and 3

40. Three different resistors R_1 , R_2 and R_3 are connected in parallel to a battery. Suppose R_1 has 2 V across it, $R_2 = 4 \Omega$, and R_3 dissipates 6 W. What is the current in R_3 ?

- [A] 0.33 A [B] 0.5 A [C] 2 A [D] 3 A [E] 12 A

PHYSICSBOWL 1999

ANSWERS

1 B	21 E
2 D	22 B
3 D	23 D
4 C	24 E
5 C	25 B
6 C	26 E
7 C	27 D
8 B	28 E
9 E	29 A
10 D	30 C
11 A	31 A
12 B	32 C
13 A	33 B
14 E	34 A
15 D	35 A
16 E	36 E
17 A	37 D
18 C	38 A
19 B	39 E
20 B	40 D