PHYSICS BOWL - APRIL 22, 1998

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.

Fifteen winning schools will receive a merchandise certificate from Metrologic Instruments. The ten highest scoring students will receive $1000 scholarships. Sixty additional students, two from each region/division, will receive $100 scholarships. All participating students will be recognized with a certificate from AAPT and Metrologic Instruments.

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: Enter your information and answers on the answer sheet provided. Write your name in the indicated space. In the block labeled "WRITE I.D. NUMBER HERE," write in and encode the ten-digit identification number your teacher gives you. Be sure to use a #2 pencil, fill the area 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.

acceleration due to gravity	g	$= 10\ \text{m/s}^2$
gravitational constant	G	$= 6.7 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2$
specific heat of water	c_w	$= 1.0\ \text{kcal/kg·K} = 4.2 \times 10^3\ \text{J/kg·K}$
atomic mass unit	1 u	$= 1.7 \times 10^{-27}\ \text{kg} = 9.3 \times 10^2\ \text{MeV/c}^2$
electron volt	1 eV	$= 1.6 \times 10^{-19}\ \text{J}$
rest mass of electron	m_e	$= 9.1 \times 10^{-31}\ \text{kg}$
rest mass of proton	m_p	$= 1.7 \times 10^{-27}\ \text{kg}$
electronic charge	e	$= 1.6 \times 10^{-19}\ \text{C}$
Coulomb's constant	k	$= 9.0 \times 10^9\ \text{N·m}^2/\text{C}^2$
permittivity constant	ϵ_0	$= 8.9 \times 10^{-12}\ \text{C}^2/\text{N·m}^2$
permeability constant	μ_0	$= 4\pi \times 10^{-7}\ \text{T·m/A}$
speed of sound in air (20°C)	v_s	$= 340\ \text{m/s}$
speed of light in vacuum	c	$= 3.0 \times 10^8\ \text{m/s}$
Planck's Constant	h	$= 6.6 \times 10^{-34}\ \text{J·s} = 4.14 \times 10^{-15}\ \text{eV·s}$

$x = v_0 t + \frac{1}{2}at^2$

$v_f = v_0 + at$

$\bar{v} = \frac{\Delta x}{\Delta t}$

$v_f^2 = v_0^2 + 2a\Delta x$

$v_{0x} = v_0 \cos\theta$

$v_{0y} = v_0 \sin\theta$

$a_c = \frac{v^2}{r}$

$\sum \mathbf{F} = m\mathbf{a}$

$F_g = mg$

$F_g = G\frac{m_1 m_2}{r^2}$

$\mathbf{p} = m\mathbf{v}$

$W = Fs\cos\theta = F_{\|}s = Fs_{\|}$

$E_k = \frac{1}{2}mv^2$

$E_p = mgh$

$E_p = \frac{1}{2}kx^2$

$P = \frac{W}{\Delta t} = Fv\cos\theta = F_{\|}v$

$\tau = RF\sin\theta = RF_{\perp} = R_{\perp}F$

$\sum \boldsymbol{\tau} = I\boldsymbol{\alpha}$

$n = \frac{c}{v}$

$v = f\lambda$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n\lambda = d\frac{x_n}{L} = d\sin\theta_n$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$m = -\frac{d_i}{d_o}$

$Q = mc\Delta T$

$Q = mL$

$\Delta U = Q - W$

$pV = nRT$

$W = p\Delta V$

$F_e = k\frac{q_1 q_2}{r^2}$

$\mathbf{E} = \frac{\mathbf{F}}{q}$

$V = \frac{W}{q}$

$V = k\frac{q}{r}$

$V = Ed$

$Q = CV$

$V = RI$

$P = VI$

$F = qvB\sin\theta = qvB_{\perp}$

$F = ILB\sin\theta = ILB_{\perp}$

$B = \frac{\mu_0 I}{2\pi r}$

$B = \mu_0 nI$

$emf = BLv$

$E = mc^2$

$E = hf$

$p = \frac{h}{\lambda}$

Nuclear notation: ${}^{A}_{Z}X$ where A is the atomic mass number and Z is the nuclear charge.

Quantities in bold type are vectors. Quantities in regular type are scalars or the magnitude of vectors.

Important!

Because of the new student scholarships this year, we are not requiring last year's winners to enter the championship region.

IDENTIFICATION NUMBER

Use the instructions below to form your ten-digit identification number

___ ___ ___ ___ ___ ___ ___ ___ _0_ _0_

Region Div. Mail code

Region: If you attend a specialized science and math school, enter "20" in the region boxes and proceed to the division instructions. If not, find your state, province, or other geographic region in the following list and enter its two digit code in the region boxes.

02	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
03	New York, Maritime Provinces, Ontario, Quebec
04	New Jersey, Pennsylvania
05	Delaware, District of Columbia, Maryland, North Carolina, Virginia
06	Florida, Georgia, South Carolina, Puerto Rico, Virgin Islands
07	Kentucky, Ohio, West Virginia
08	Indiana, Michigan
09	Illinois, Iowa
10	Minnesota, North Dakota, South Dakota, Wisconsin
11	Alabama, Arkansas, Louisiana, Mississippi, Tennessee
12	Colorado, Kansas, Missouri, Nebraska, Oklahoma, Wyoming
13	Arizona, New Mexico, Texas, Utah
14	California, Hawaii, Nevada, American Samoa, Guam
15	Alaska, Idaho, Montana, Oregon, Washington, Alberta, British Columbia, Manitoba, Saskatchewan, and others
20	Specialized Science and Math Schools

Division: Enter a "1" for division I (first-year physics students) or a "2" for division II (second-year physics students) in the Div. box.

Mail code: If your school's address has a five-digit ZIP code, enter it in the mail code boxes. If your school's address has a six character postal code, enter "00" followed by the *numbers* in your school's postal code. If your school's address has neither, enter "00000".

1. Which of the following is not a vector quantity?

A. acceleration B. electric field C. energy D. force E. velocity

2. An observer hears a sound with frequency 400 Hz. Its wavelength is approximately

A. 0.85 m B. 1.2 m C. 2.75 m D. 13.6 m E. 44 m

3. An object in equilibrium has three forces, F_1 of 30 N, F_2 of 50 N, and F_3 of 70 N, acting on it. The magnitude of the resultant of F_1 and F_2 is

A. 10 N B. 20 N C. 40 N D. 70 N E. 80 N

4. As sound travels from steel into air, both its speed and its:

A. wavelength increase.
B. wavelength decrease.
C. frequency increase.
D. frequency decrease.
E. frequency remain unchanged.

5. Which of the following temperatures would be most appropriate to keep milk at inside a refrigerator?

A. –20ºC B. 5 K C. 40ºC D. 278 K E. 350 K

6. When any four resistors are connected in parallel, the _______ each resistor is the same.

A. charge on B. current through C. power from D. resistance of E. voltage across

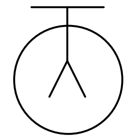
7. A heat engine takes in 200 J of thermal energy and performs 50 J of work in each cycle. What is its efficiency?

A. 500 % B. 400 % C. 25 % D. 20 % E. 12 %

8. When two charged point-like objects are separated by a distance R, the force between them is F. If the distance between them is quadrupled, the force between them is

A. 16 F B. 4 F C. F D. $F/4$ E. $F/16$

9. An electroscope is given a positive charge, causing its foil leaves to separate. When an object is brought near the top plate of the electroscope, the foils separate even further. We could conclude



A. that the object is positively charged.
B. that the object is electrically neutral.
C. that the object is negatively charged.
D. only that the object is charged.
E. only that the object is uncharged.

10. A charged particle with constant velocity enters a uniform magnetic field whose direction is parallel to the particle's velocity. The particle will

A. speed up.
B. slow down.
C. experience no change in velocity.
D. follow a parabolic arc.
E. follow a circular arc.

11. In the nuclear reaction $^{6}_{3}\mathrm{Li} + ? \rightarrow ^{7}_{3}\mathrm{Li}$ the "?" represents

A. an alpha particle B. a deuteron C. an electron D. a neutron E. a proton

12. An alpha particle is the same as
A. a helium nucleus B. a positron C. an electron D. a high energy photon E. a deuteron

13. When a falling object moves with terminal velocity, it

A. has zero velocity.
B. has zero acceleration.
C. has an upward acceleration.
D. is no longer subject to air resistance.
E. has an acceleration of approximately 10 m/s^2.

14. How long must a 2.5 m/s^2 acceleration act to change the velocity of a 2.0-kg object by 3.0 m/s?

A. 0.83 s B. 1.2 s C. 1.7 s D. 2.5 s E. 7.5 s

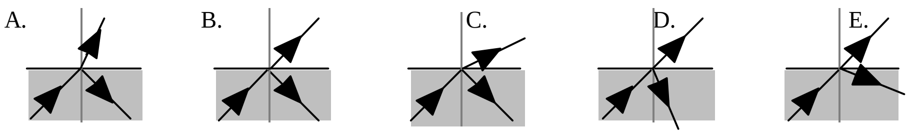
15. A freely falling object is found to be moving downward at 18 m/s. If it continues to fall, two seconds later the object would be moving with a speed of

A. 8.0 m/s B. 10 m/s C. 18 m/s D. 38 m/s E. 180 m/s

16. If the unit for force is F, the unit for velocity V, and the unit for time T, then the unit for momentum is

A. FT　　B. FTV　　C. FT^2V　　D. FT/V　　E. FV/T

17. Which diagram best represents what happens to a ray of light entering air from water? Air is at the top in all diagrams.



18. When a train is at rest, both a passenger on the train and a ticket seller on the station agree that the trains whistle produces sound at a frequency of 120 Hz. When the train is moving away from the station at 15 m/s, the passenger hears a frequency of _____ Hz and the ticket seller hears a frequency of ____ Hz.

A. 120, 125　　B. 115, 120　　C. 120, 120　　D. 115, 115　　E. 120, 115

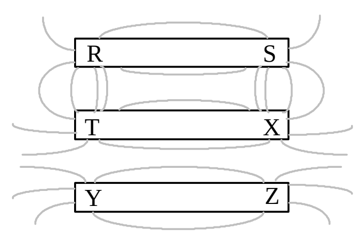
19. In order to produce an enlarged, upright image of an object, you could use a

A. converging lens more than one focal length from the object.
B. converging lens less than one focal length from the object.
C. diverging lens more than one focal length from the object.
D. diverging lens exactly one focal length from the object.
E. diverging lens less than one focal length from the object.

20. Wire I and wire II are made of the same material. Wire II has twice the diameter and twice the length of I. If I has resistance R, II has resistance

A. $R/8$　　B. $R/4$　　C. $R/2$　　D. R　　E. $2R$

21. The diagram to the right depicts iron filings sprinkled around three permanent magnets. Pole R is the same as poles

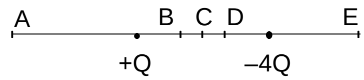


A. T and Y
B. T and Z
C. X and Y
D. X and Z
E. S, T, and Z

22. A rotating fan blade has kinetic energy K when rotating with constant angular velocity. When the angular velocity is reduced to one-third, the kinetic energy becomes

A. $9K$　　B. $3K$　　C. K　　D. $K/3$　　E. $K/9$

23. Two charges +Q and –4Q are arranged as shown in the accompanying diagram. At which of the labeled points is the field most nearly zero?



A. A B. B C. C D. D E. E

24. A planet has a radius one-half that of Earth and a mass one-fifth the Earth's mass. The gravitational acceleration at the surface of the planet is most nearly

A. 4.0 m/s^2 B. 8.0 m/s^2 C. 12.5 m/s^2 D. 25 m/s^2 E. 62.5 m/s^2

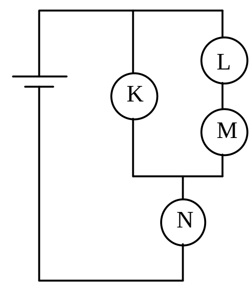
25. A car whose mass is 1200 kg is accelerated from rest by a constant force of 2400 N. What is the speed of the car 8.0 s after beginning?

A. 0.40 m/s B. 1.6 m/s C. 4.0 m/s D. 8.0 m/s E. 16 m/s

26. A ball with a mass of 0.50 kg and a speed of 6.0 m/s collides perpendicularly with a wall and bounces off with a speed of 4.0 m/s in the opposite direction. What is the magnitude of the impulse acting on the ball?

A. 13 J B. 1.0 N s C. 5.0 N s D. 2.0 m/s E. 10 m/s

27. Four identical light bulbs K, L, M, and N are connected in the electrical circuit shown in the accompanying diagram. Rank the current through the bulbs.



A. K > L > M > N
B. L = M > K = N
C. L > M > K > N
D. N > K > L = M
E. N > L = M > K

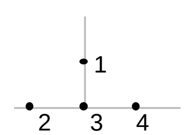
28. A solid disk has mass m, radius r, and rotational inertia $(1/2)mr^2$. The disk is initially at rest. A constant force F acts tangential to the rim. What is the angular acceleration of the disk?

A. $\frac{m}{Fr^2}$ B. $\frac{F}{mr}$ C. $\frac{F}{2mr^2}$ D. $\frac{2F}{mr^2}$ E. $\frac{2F}{mr}$

29. A 50-kg student stands on a scale in an elevator. At the instant the elevator has a downward acceleration of 1.0 m/s^2 and an upward velocity of 3.0 m/s, the scale reads approximately

A. 350 N B. 450 N C. 500 N D. 550 N E. 650 N

30. Four positive point charges are arranged as shown in the accompanying diagram. The force between charges 1 and 3 is 6.0 N; the force between charges 2 and 3 is 5.0 N; and the force between charges 3 and 4 is 3.0 N. The magnitude of the total force on charge 3 is most nearly



A. 6.3 N B. 8.0 N C. 10 N D. 11 N E. 14 N

31. An object sliding down an inclined plane has speed 0.40 m/s two seconds after it begins to slide. Approximately how far does it travel in three seconds?

A. 0.15 m B. 0.30 m C. 0.45 m D. 0.60 m E. 0.90 m

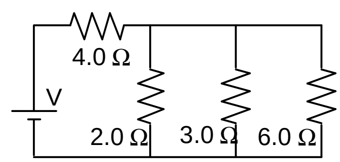
32. A 3.0-kg block with initial speed 4.0 m/s slides across a rough horizontal floor before coming to rest. The frictional force acting on the block is 3.0 N. How far does the block slide before coming to rest?

A. 1.0 m B. 2.0 m C. 4.0 m D. 8.0 m E. 16 m

33. In the following problem, the word “weight” refers to the force a scale registers. If the Earth were to stop rotating, but not change shape,

A. the weight of an object at the equator would increase.
B. the weight of an object at the equator would decrease.
C. the weight of an object at the north pole would increase.
D. the weight of an object at the north pole would decrease.
E. all objects on Earth would become weightless.

34. In the accompanying circuit diagram, the current through the 6.0-Ω resistor is 1.0 A. What is the power supply voltage *V*?



A. 10 V
B. 18 V
C. 24 V
D. 30 V
E. 42 V

35. A pipe that is closed at one end and open at the other resonates at a fundamental frequency of 240 Hz. The next lowest/highest frequency it resonates at is most nearly

A. 60 Hz B. 80 Hz C. 120 Hz D. 480 Hz E. 720 Hz

36. The critical angle in a transparent substance surrounded by air is 30°. The speed of light in the substance (in multiples of 10^8 m/s) is most nearly

A. 1.0 B. 1.5 C. 2.0 D. 3.0 E. 6.0

37. Two isolated parallel plates are separated by a distance *d*. They carry opposite charges *Q* and each has surface area *A*. Which of the following would increase the strength of the electric field between the plates?

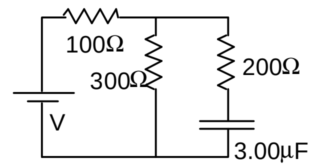
I. Increasing *Q*
II. Increasing *A*
III. Increasing *d*

A. I only B. II only C. III only D. I & III only E. II & III only

38. A uniform meter stick of mass 0.20 kg is pivoted at the 40-cm mark. Where should one hang a mass of 0.50 kg to balance the stick?

A. 16 cm B. 36 cm C. 44 cm D. 46 cm E. 54 cm

39. In the circuit diagrammed to the right, the 3.00-μF capacitor is fully charged at 18.0 μC. What is the value of the power supply voltage *V*?



A. 4.40 V
B. 6.00 V
C. 8.00 V
D. 10.4 V
E. 11.0 V

40. Coin I is thrown upward from the top of a 100-m tower with a speed of 15 m/s. Coin II is dropped (zero initial speed) from the top of the tower 2.0 s later. Assume g is 10 m/s^2. How far below the top of the tower does coin I pass coin II?

A. 1.6 m B. 16 m C. 20 m D. 80 m E. 96 m

PHYSICSBOWL

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1998 Physics Bowl

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