UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

2016 Saskatchewan High School Physics Scholarship Competition

Wednesday May 11, 2016 Time allowed: 90 minutes

This competition is based on the Saskatchewan High School Physics Curriculum.

INSTRUCTIONS:

1. You should have a test paper and an OMR (Optical Machine Readable) or Computer scan sheet. The test paper consists of 7 pages, including this cover page. **The student should check that the test paper is complete**.
2. Enter your **name** and **school** on the OMR sheet.
3. Enter your personal information on the table below.
4. At the end of the examination **only this cover page and the OMR sheet** must be submitted.
5. All questions are of equal value.
6. Marks are awarded for correct answers only. No marks will be deducted for wrong answers.
7. Calculators may **not** be used. (None of the questions require the use of a calculator.)

PLEASE **PRINT** THE FOLLOWING INFORMATION

Name: _____

School: _____

Physics Teacher: _____

Home Address: _____

_____

_____

Postal Code: _____

Telephone: _____

Email address: _____

FOR EACH OF THE FOLLOWING QUESTIONS ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

Note: In all the questions the symbol *g* denotes the magnitude of the acceleration due to gravity on the Earth's surface.

1. The mass of a grain of sugar is measured and the result is quoted to be 0.00060 grams. How many significant figures are in this result?

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

2. The length of an iron bar is measured when the bar is at a temperature of 20°C. If the temperature of the bar is increased to 40°C we find that the length of the bar has increased by 0.024%. If the temperature of the bar is increased to 60°C, what is the length of the bar now compared to when it was 20°C?

(A) It is 0.024% longer.
(B) It is 0.036% longer.
(C) It is 0.048% longer.
(D) It is 0.060% longer.
(E) It is 0.088% longer.

3. You want to know how much the temperature of a particular piece of material, with known mass, will rise when a known amount of heat is added to it. Which one of the following would it be necessary to know?

(A) The material's thermal conductivity.
(B) The material's density.
(C) The material's initial temperature.
(D) The material's coefficient of linear expansion.
(E) The material's specific heat capacity.

4. Suppose you empty a tray of ice cubes into a bowl partly filled with water and then cover the bowl. After half an hour, the contents of the bowl come to thermal equilibrium, with more water and less ice than you started with. Which one of the following statements is true?

(A) The temperature of the liquid water is higher than the temperature of the remaining ice.
(B) The temperature of the liquid water is the same as the temperature of the remaining ice.
(C) The temperature of the liquid water is lower than the temperature of the remaining ice.
(D) The comparative temperatures of the liquid water and that of the ice depend on the amounts present.

5. A periodic wave is made to travel along a string by someone wiggling the end of the string back and forth. The distance between wave crests is 0.50 m and it is observed that the wave crests move along the string at a speed of 2.0 m/s. What is the frequency of oscillation of each piece of the string as the wave passes by?

(A) 0.5 Hz (B) 1.0 Hz (C) 2.0 Hz (D) 4.0 Hz (E) 8.0 Hz

6. You stretch a rubber hose and pluck it. You observe a pulse travelling along the hose and back. What happens to the speed of the pulse if you stretch the hose more tightly?

(A) It moves more rapidly.
(B) It moves more slowly.
(C) Its speed does not change.
(D) It can be faster or slower, it depends on how large the wave pulse is.
(E) It can be faster or slower, it depends on how thick the hose it.

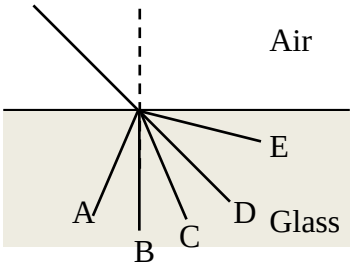
7. By plucking and touching a guitar string in just the right way, a guitarist can make the string vibrate in its third harmonic. If the length of the string is L what must be the wavelength of the waves moving in the string when it is vibrating in the third harmonic?

(A) $\frac{3}{4}L$ (B) $\frac{1}{2}L$ (C) $\frac{1}{3}L$ (D) $\frac{2}{3}L$ (E) $\frac{3}{2}L$

8. A man walks directly toward a flat mirror along a line that is perpendicular to the mirror surface. He walks at a speed of 4 m/s. How fast does he approach his image?

(A) 2 m/s (B) 4 m/s (C) 6 m/s (D) 8 m/s (E) 12 m/s

9. Shown here are some possible paths followed by a ray of light as it passes from air into glass or from glass into air. We are not told in which direction the light is going. Which is a possible path for the light ray?



(A) Path A
(B) Path B
(C) Path C
(D) Path D
(E) Path E
(F) We cannot tell which path was followed without knowing in which direction the light was going.

10. Total internal reflection can occur when light travelling in medium 1 is incident on an interface with medium 2. For total internal reflection to occur, which statement must be correct?

(A) The index of refraction in medium 1 must be smaller than in medium 2.
(B) The speed of light in medium 1 must be larger than in medium 2.
(C) The speed of light in medium 1 must be smaller than in medium 2.
(D) The speed of light in medium 1 must be the same as in medium 2.
(E) The index of refraction in medium 1 must be the same as in medium 2.

11. A concave mirror has a focal length f. An object is placed at a distance between f and $2f$ from the surface of the mirror. Which statement is correct concerning the image formed by the mirror?

(A) The image is upright and larger than the object.
(B) The image is upright and smaller than the object.
(C) The image is upside down and smaller than the object.
(D) The image is upside down and larger than the object.
(E) No image is formed in this situation.

12. A magnifying glass is used to make something you are looking at appear larger. A simple magnifier is a converging lens of focal length *f*. When it is used to look at a spider the lens is held close to the eye. For the image you see of the spider to be larger than the spider itself, which statement is correct concerning the distance between the lens and the spider?

(A) The spider to lens distance must be less than the distance between the lens and your eye.
(B) The spider to lens distance must be less than or equal to *f*.
(C) The spider to lens distance must be greater than *f*.
(D) The spider to lens distance must be greater than 2*f*.

13. We are told only that a car is travelling at a constant speed. Which one of the following statements is a correct conclusion we can make?

(A) The car has a constant velocity.
(B) The car has zero acceleration.
(C) The car must be moving in a straight line.
(D) The car must be moving in a circle.
(E) The car must be moving on a flat horizontal surface.
(F) We can make none of the above conclusions with certainty.

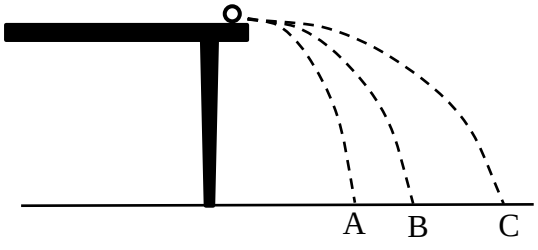
14. Suppose you take a car trip of 300 km. For the first 150 km you travel at a speed V_1 and for the second 150 km you travel at a speed V_2 which is larger than V_1. What can you say about your average speed for the whole 300 km trip?

(A) The average speed is $\frac{1}{2}(V_1 + V_2)$.
(B) The average speed is closer to V_1 than it is to V_2.
(C) The average speed is closer to V_2 than it is to V_1.
(D) We must know the actual speeds involved to determine if the average speed is closer to V_1 or to V_2.
(E) The average speed is zero.

15. A car moves in a straight line. It starts from rest and maintains a constant acceleration. After 2 seconds it is a distance *d* from its starting position. How far is it from its starting position when it has been moving for 4 seconds?

(A) 2*d* (B) 3*d* (C) 4*d* (D) 6*d* (E) 8*d*

16. Balls roll off a horizontal table with different speeds and follow the trajectories shown. We can neglect air resistance. For which ball will the time between leaving the table and hitting the floor be the greatest?



(A) The ball following path A.
(B) The ball following path B.
(C) The ball following path C.
(D) The ball following either path A, B or C depending on which ball has the lower mass.
(E) The balls following paths A, B and C will all have the same flight time.

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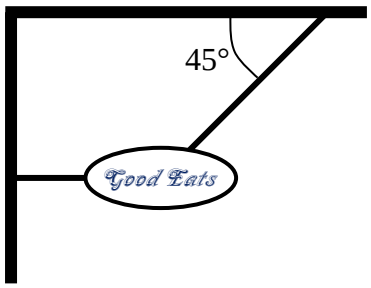
17. Two "tug-of-war" teams each pull on the opposite ends of a horizontal rope. Each team exerts the same magnitude horizontal force of 4000 N. The tension in the rope is

(A) zero.
(B) 2000 N.
(C) 4000 N.
(D) 8000 N.
(E) not possible to determine with the information given.

18. A store sign is held in place by two ropes: a horizontal rope that attaches to a wall and a rope at an angle of 45° that is attached to the roof. The tension in the horizontal rope is T. What is the weight of the sign?

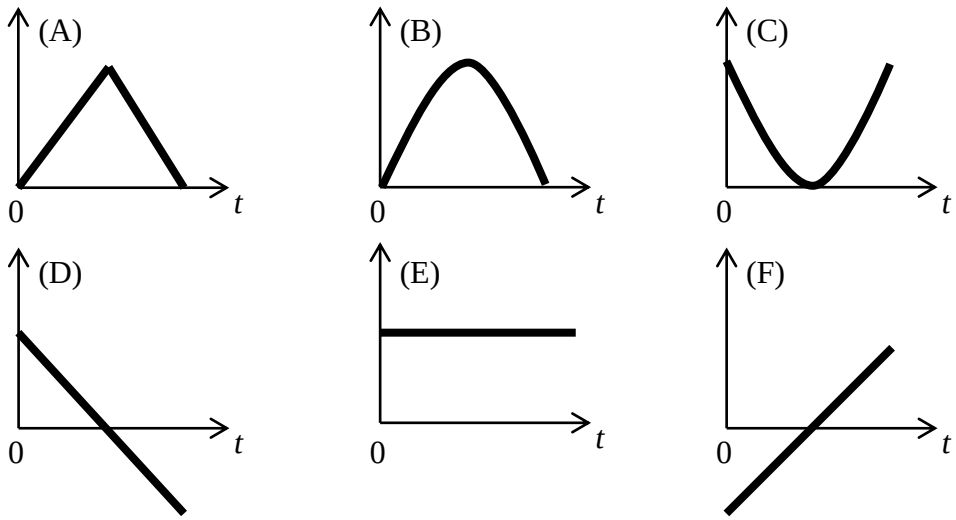


(A) T
(B) $\sqrt{2}\,T$
(C) $T/\sqrt{2}$
(D) $2T$
(E) $T/2$

19. A garbage truck collides head on with a small car and the two come to rest in a cloud of flies. Which vehicle experiences the force with greatest magnitude during the time of the collision?

(A) The car.
(B) The garbage truck.
(C) Both experience the same magnitude force.
(D) Not enough information is given to determine an answer.

20. A stone is thrown vertically upward. Air resistance can be ignored. It is thrown at time $t = 0$. Which graph below best represents the gravitational potential energy of the stone, as a function of time, during its flight?



21. A tank car coasts along a straight section of horizontal rail line. Friction may be ignored in the motion of the car. The tank develops a leak in its bottom and dribbles several thousand gallons of water onto the ground. In the process the tank car (including whatever contents it has remaining)…

(A) speeds up.
(B) slows down.
(C) gains momentum.
(D) loses momentum.
(E) gains kinetic energy.

22. An object that is initially at rest explodes, breaking apart into three pieces, each with the same mass. Just after the explosion part 1 has velocity $\vec{\mathbf{v}}_1$ with speed v, part 2 has velocity $\vec{\mathbf{v}}_2$ with speed $2v$. The velocity vectors $\vec{\mathbf{v}}_1$ and $\vec{\mathbf{v}}_2$ are perpendicular to each other. What is the speed of the third piece?

(A) $2v$ (B) $3v$ (C) $\sqrt{2}\,v$ (D) $\sqrt{3}\,v$ (E) $\sqrt{5}\,v$

23. What is the acceleration due to gravity on the surface of a planet which has a mass that is 2 times the mass of the Earth and a radius that is 2 times the radius of the Earth?

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

24. An astronaut in a space ship is wondering if his ship is actually moving forward. There are no windows he can see out of. How can he tell if he is in motion?

(A) He can observe the contraction of an on-board metre stick.
(B) He can observe the slowing down of on-board clocks.
(C) He can observe the speeding up of his own heart.
(D) More than one of the above observations will work.
(E) None of the above observations will allow him to tell if he is in motion.

25. Einstein's explanation of the photoelectric effect showed that…

(A) light behaves like a wave.
(B) electrons exhibit wave-like behaviour.
(C) light consists of energy quanta that behave like particles.
(D) a surface radiates energy at a rate that is related to its temperature.
(E) light of any wavelength can eject electrons from a surface.

26. A radioactive nucleus undergoes alpha-particle decay. Compared to the parent nucleus, the daughter nucleus has…

(A) the same atomic number (Z) but the nucleon number (A) reduced by 4.
(B) the atomic number (Z) reduced by 4 and the nucleon number (A) reduced by 2.
(C) the atomic number (Z) reduced by 2 and the nucleon number (A) reduced by 2.
(D) the atomic number (Z) reduced by 2 and the nucleon number (A) reduced by 4.
(E) the atomic number (Z) reduced by 2 but the same nucleon number (A).

27. A radioactive nucleus has a half life of 10 days. A sample is prepared that has a certain number of these radioactive nuclei in it. After 30 days, what percentage of these nuclei remain?

(A) 66%
(B) 30%
(C) 25%
(D) 12.5%
(E) 10%
(F) None

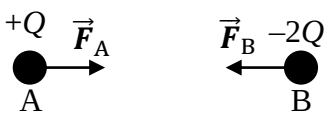
28. When a radioactive nucleus decays it breaks apart into smaller pieces known as decay products. Let the mass of the original nucleus be m_i and the sum of the masses of all the decay products be m_f. What is the relationship between these masses?

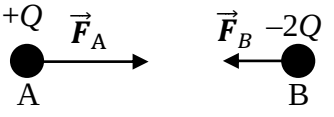
(A) $m_f = m_i$
(B) $m_f < m_i$
(C) $m_f > m_i$
(D) It could be that $m_f < m_i$, $m_f = m_i$, or $m_f > m_i$ depending on the particular radioactive nucleus.

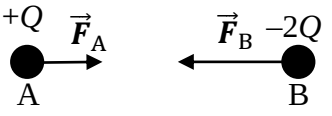
29. At present, the energy generated within the Sun, which is radiated to reach us on Earth, is powered by…

(A) cosmic rays hitting the sun.
(B) the decay of radioactive nuclei within the Sun.
(C) nuclear fission reactions occurring within the Sun.
(D) thermonuclear fusion reactions occurring within the Sun.
(E) the gravitational collapse of the material which formed the Sun.

30. Two small objects have each been given an electric charge. Object A has a positive charge of magnitude Q and object B has a negative charge of magnitude $2Q$. Which one of the following diagrams give the best representation of the electrostatic force vectors, $\vec{F}_A$ and $\vec{F}_B$, on each of the objects?

(A) 

(B) 

(C) 

(D) 

(E) 

(F) 

END OF EXAMINATION