UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

2015 Saskatchewan High School Physics Scholarship Competition

May 13, 2015   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 9 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 <u>magnitude</u> of the acceleration due to gravity on the Earth's surface.

1. To determine the area of a rectangular field I measured the width to be 22.6 m and the length to be 35.05 m. I find the area by multiplying the width by length and my calculator display reads "792.130". What is the best way to write my answer in scientific notation with the correct number of significant figures?
   (A) 792 m^2
   (B) 792.1 m^2
   (C) 7.92×10^2 m^2
   (D) 7.921×10^2 m^2
   (E) 7.9213×10^2 m^2

2. Which one of the following statements is correct?
   (A) Heat and temperature are really the same thing.
   (B) In principle there is no lower limit for the temperature one could reach, provided a sufficiently good refrigerator could be built.
   (C) Absolute zero refers to the temperature of a water-ice mixture in equilibrium on the Celsius scale.
   (D) If the average kinetic energy of the molecules in a substance increases, that means the temperature of the substance increases.
   (E) Heat is measured in the same units as a force.

3. Consider two solid objects which have different masses and are made of different materials. The amount of heat required to raise the temperature of each by 10°C will
   (A) be greater for the more massive object.
   (B) be greater for the less massive object.
   (C) be the same for both objects.
   (D) possibly be greater for either object depending on what they are made of.

4. Heat is added at a constant rate to an object that was a solid at time $t = 0$. The temperature of the object is recorded as a function of time and is plotted on the graph. Which statement is true?
   (A) At time 20 minutes the substance was a mixture of liquid and gas.
   (B) At time 30 minutes the substance was all gas.
   (C) At time 20 minutes the substance was a mixture of solid and liquid.
   (D) At time 20 minutes the substance was all solid.
   (E) At time 40 minutes the substance was a mixture of liquid and gas.
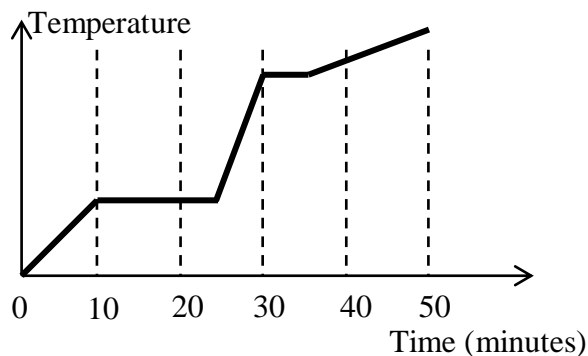
5. Consider a transverse wave in a string that is caused by someone wiggling the end of the string back and forth. Which one of the following options describes the quantity or quantities that determine the speed of the wave along the string?

(A) The amplitude of the wiggling.
(B) The frequency of the wiggling.
(C) The period of the wiggling (i.e. the time for one wiggle).
(D) The mass per unit length of the string and the tension of the string.

6. Consider the superposition of two waves with identical amplitudes and identical wavelengths, travelling along a string. The amplitude of each wave is A. At a particular instant in time what is the amplitude of the resultant wave?

(A) It is A.
(B) It is $2A$.
(C) It is $\frac{1}{2}A$.
(D) It can be anywhere between $\frac{1}{2}A$ and A.
(E) It can be anywhere between zero and $2A$.

7. A guitar string of length L is fixed at both ends. The string is made to vibrate at a frequency such that there are 2 nodes in the string (not counting the nodes at the fixed ends). What is the wavelength of the wave in the string?

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

8. When light passes from air into water what changes occur?

(A) The speed of the light decreases and its wavelength decreases.
(B) The speed of the light decreases and its frequency increases.
(C) The speed of the light increases and its wavelength increases.
(D) The frequency of the light decreases and its wavelength increases.
(E) The frequency of the light increases and its wavelength decreases.

9. A light ray hits the interface between air and glass at an angle of incidence θ as shown. Which statement is correct?

(A) The angle of reflection is less than the angle of incidence.
(B) The angle of refraction is less than the angle of incidence.
(C) The angle of refraction is greater than the angle of incidence.
(D) The angle of refraction is equal to the angle of incidence.
(E) The angle of refraction is equal to the angle of reflection.
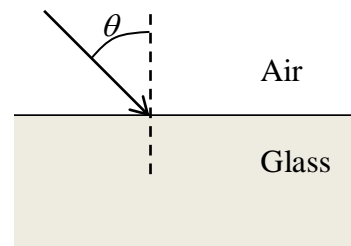
10. Consider the image formed by a convex spherical mirror when the object is placed at a distance in front of the mirror equal to the magnitude of the focal length of the mirror. Which statement is correct?

    (A)   The image is an infinite distance away.
    (B)   The image is virtual, upright and smaller than the object.
    (C)   The image is real, inverted and smaller than the object.
    (D)   The image is virtual, inverted and larger than the object.
    (E)   The image is real, upright and larger than the object.

11. The diagram shows four rays drawn from the head of the object arrow through a thin converging lens to locate its image. The points labelled F are the focal points of the lens. Are any of the rays drawn incorrectly?
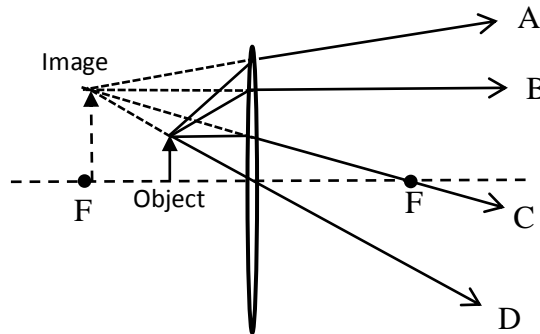

    (A)   Ray A is drawn incorrectly.
    (B)   Ray B is drawn incorrectly.
    (C)   Ray C is drawn incorrectly.
    (D)   Ray D is drawn incorrectly.
    (E)   All four rays are drawn correctly.

12. If you were to inhale a few breaths of helium gas, you would probably experience an amusing change in your voice. You would sound like a relative of Donald Duck or Alvin the chipmunk. What is the cause of this curious effect?

    (A)   The helium causes your vocal cords to tighten and vibrate at a higher frequency.
    (B)   For a given frequency of vibration in the gas in your throat, the wavelength of the sound is less in helium than it is in air.
    (C)   Your vocal cords are resonating in their second harmonic, rather than at their fundamental frequency.
    (D)   Low frequencies are absorbed by the helium gas, leaving only the high frequency components.
    (E)   Sound travels faster in helium than in air, so the same wavelength sound will have a higher frequency.

13. You hear that the horn on a car emits a sound with a certain frequency and wavelength when you are standing still and the car is stationary. Later, you are standing still and the car is moving toward you when the horn is sounded. What has happened to the sound reaching your ear, compared to when the car was stationary?

    (A)   The sound you hear has a higher frequency and a longer wavelength.
    (B)   The sound you hear has a higher frequency and a shorter wavelength.
    (C)   The sound you hear has a lower frequency and a longer wavelength.
    (D)   The sound you hear has the same frequency and a shorter wavelength.
   (E)   The sound you hear has a higher frequency and the same wavelength.

14. The particle nature of light is most clearly demonstrated by which phenomenon?

    (A)   The photoelectric effect.
    (B)   The interference pattern in a double slit experiment.
    (C)   The refraction of light.
    (D)   The Doppler effect.
    (E)   Dispersion of light by a prism.

15. The neutral atom of an isotope of Beryllium has 4 electrons in orbit around the nucleus. The nucleus of this isotope has a total of 9 nucleons (neutron and protons) in it. How many neutrons does this nucleus contain?

    (A)   3
    (B)   4
    (C)   5
    (D)   6
    (E)   9

16. Two objects are dropped from the top of a tall building. You may ignore air resistance for this problem. Object A, which has a mass of 2 kg, hits the ground 4 seconds after it was dropped. Object B has a mass of 4 kg. How long after object B was dropped will it take for it to hit the ground?

    (A)   1 second
    (B)   2 seconds
    (C)   4 seconds
    (D)   8 seconds
    (E)   16 seconds

17. The velocity of a car as a function of time is plotted on the graph. How far did the car travel in the period of time between $t = 0$ and $t = 10$ s?

    (A)   25 m
   (B)   20 m
    (C)   15 m
    (D)   10 m
    (E)   5 m
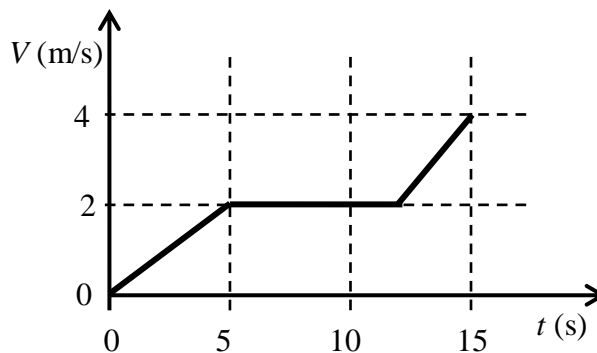
18. I go on a 30-km bicycle trip. I go the first 10 km at a speed of 10 km/h. I then go the remaining 20 km at a speed of 5 km/h. What was my average speed for the whole 30-km trip?

    (A)   5 km/h
    (B)   6 km/h
    (C)   7 km/h
    (D)   7.5 km/h
    (E)   8 km/h

19. To figure out the depth of a mine shaft I drop a stone into it and start counting, "one alligator, two alligator, three alligator …", until I hear the stone hit the bottom. If I know a "two alligator" mine shaft has a depth h, approximately how deep is a "four alligator" mine shaft?

   (A) $2h$
   (B) $\sqrt{2}h$
   (C) $4h$
   (D) $2\sqrt{2}h$
   (E) $8h$

20. Two balls are thrown from the top of a building and they each eventually hit the horizontal ground below. You may ignore air resistance. The blue ball is thrown horizontally with speed V and the red ball is thrown directly downward with the same speed V. Just before it hits the ground the blue ball has speed V_{blue}, and just before the red ball hits the ground it has speed V_{red}. How do these two speeds compare?

   (A) V_{blue} will be greater than V_{red}.
   (B) V_{blue} will be equal to V_{red}.
   (C) V_{blue} will be smaller than V_{red}.
   (D) We do not have enough information to decide on an answer.

21. A 10 kg mass and a 4 kg mass are each acted on by the same net force (which remains constant) for the same period of time. Both masses are at rest before the force is applied. The distance the 10 kg mass moves in this time period is x_1, and the distance the 4 kg mass moves in the same time period is x_2. Which statement is correct?

   (A) $x_2 = x_1$
   (B) $x_2 = \frac{5}{2} x_1$
   (C) $x_2 = \frac{2}{5} x_1$
   (D) $x_2 = \left(\frac{5}{2}\right)^2 x_1$
   (E) $x_2 = \left(\frac{2}{5}\right)^2 x_1$

22. A block of mass m has been released and is sliding down a frictionless plane which is inclined at an angle θ to the horizontal. What is the magnitude of the net force on the block?

   (A) mg
   (B) $mg \cos \theta$
   (C) $mg \tan \theta$
   (D) $mg \sin \theta$
   (E) zero
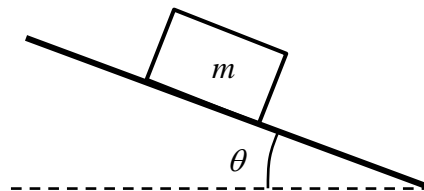
23. A box, with mass m, is being pulled along a horizontal surface with a constant horizontal force of magnitude F as shown. The box moves at a constant velocity. The coefficient of kinetic friction between the box and the surface is μ_k. What must be the magnitude of F?

(A) $F = \mu_k mg$

(B) $F = mg$

(C) $F = \mu_k m$

(D) $F = \dfrac{mg}{\mu_k}$

(E) $F = \dfrac{m}{\mu_k}$
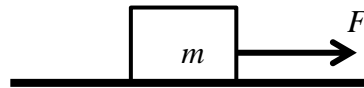
24. A refrigerator is sitting on the kitchen floor. Consider the following forces present in this situation:
1. The weight of the refrigerator.
2. The force of the refrigerator pushing down on the floor.
3. The force of the refrigerator pulling up on the Earth.
4. The force of the floor pushing up on the refrigerator.

Which pair of forces is an action-reaction pair in Newton's Third Law?

(A) Forces 1 and 2.

(B) Forces 1 and 4.

(C) Forces 2 and 3.

(D) Forces 3 and 4.

(E) Forces 1 and 3.

25. An object, with mass 2 kg, is at rest on a horizontal frictionless surface when a constant horizontal force of magnitude 4 N is applied to it. If it moves 5 m while the force is acting on it, how much kinetic energy does it gain?

(A) 8 J

(B) 10 J

(C) 20 J

(D) 50 J

(E) 100 J

26. A ball, with a weight of 10 N, is dropped from a height of 3 m. It hits the floor and rebounds to a height of 2 m. You may ignore air resistance. How much energy was converted to heat and sound in the collision of the ball with the ground?

(A) 30 J

(B) 20 J

(C) 10 J

(D) 5 J

(E) zero

27. A roller-coaster car, of mass m, is moving with speed v_1 at the top of a hill. When it reaches the bottom of the hill, at a height h below the top, it is moving with speed v_2. You may ignore frictional effects in this problem. What is the relationship between v_1 and v_2?

(A) $v_2 = v_1 + 2gh$

(B) $v_2 = \sqrt{v_1^2 + mgh}$

(C) $v_2 = \dfrac{2}{m}\sqrt{v_1^2 + 2mgh}$

(D) $v_2 = \sqrt{v_1^2 + 2gh}$

(E) $v_2 = v_1 + mgh$
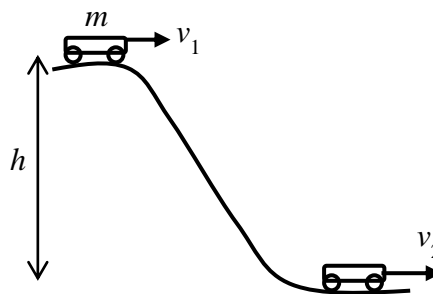
28. A rail car of mass m is moving at speed V toward a pair of identical rail cars that are stationary and are coupled together as shown. When the car collides with the other two it couples to them and so the three rail cars move together after the collision. You may ignore friction during the collision. What is the speed of the three rail cars just after the collision?

(A) $\frac{1}{4}V$

(B) $\frac{1}{3}V$

(C) $\frac{1}{2}V$

(D) $\frac{2}{3}V$

(E) $\frac{1}{\sqrt{3}}V$
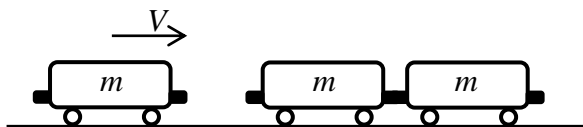
29. A ping-pong ball moving toward the East collides with a stationary bowling ball. The ping-pong ball bounces back to the West and the bowling ball moves very slowly toward the East after the collision. Which object experienced the greater magnitude average force during the time of the collision?

(A) Neither, both experience the same magnitude average force.

(B) The ping-pong ball.

(C) The bowling ball.

(D) It is impossible to tell without knowing the speed of the ping-pong ball and the actual masses of the two balls.

30. A car is moving around a circular track at a constant speed. At a particular instant, what is the direction of the acceleration of the car?

(A) It is in the same direction as the car's velocity.

(B) It is opposite in direction as the car's velocity.

(C) It is toward the centre of the circular track.

(D) It is directly away from the centre of the circular track.

(E) None of the above, the acceleration of the car is zero.

31. A car is moving around a circular track at a constant speed of magnitude *V*. The magnitude of the net force on the car is *F*. If the car now moves around the same track at double the speed (2*V*), what is the magnitude of the net force on the car?

(A) ½ *F*.

(B) *F*.

(C) 2*F*.

(D) 3*F*.

(E) 4*F*.

32. Two planets in a distant solar system have different sizes and masses. Planet Yum has a radius *R* and a mass *M*. Planet Zork has a radius 2*R* and a mass 3*M*. The acceleration due to gravity on the surface of planet Yum is g_Y. What would be the acceleration due to gravity on the surface of planet Zork?

(A) $\frac{3}{4} g_Y$

(B) $\frac{3}{2} g_Y$

(C) $\frac{9}{4} g_Y$

(D) $\frac{9}{2} g_Y$

(E) $\frac{2}{3} g_Y$

END OF EXAMINATION