UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

2014 Saskatchewan High School Physics Scholarship Competition

May 14, 2014 Time allowed: 90 minutes

This competition is based on the Saskatchewan High School Physics Curriculum for Physics 20 and Physics 30 including a few questions from the optional units.

INSTRUCTIONS:

1. You should have a test paper and an OMR (Optical Machine Readable) or Computer scan sheet. The test paper consists of 8 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: _____

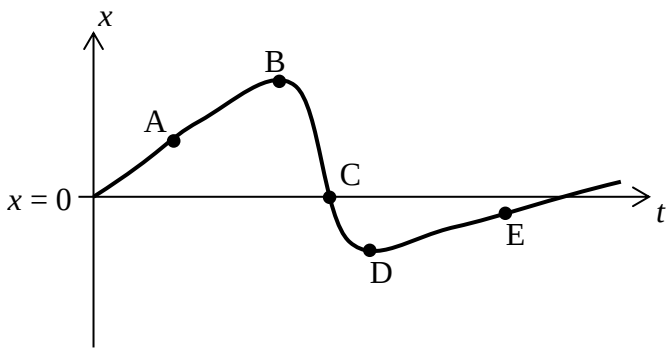
FOR EACH OF THE FOLLOWING QUESTIONS ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

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

1. How many times larger than a micrometre is ten kilometres?

(A) 10^4
(B) 10^7
(C) 10^9
(D) 10^{10}
(E) 10^{13}

2. An object moves along the *x*-axis. The graph shows the position, *x*, of the object as a function of time, *t*. At which of the marked points is the speed of the object greatest?



(A) A
(B) B
(C) C
(D) D
(E) E

3. A wave is made to travel along a stretched string by wiggling one end of the string up and down at a frequency of 4 Hz. The distance between wave crests is 2 m. What is the speed of the wave along the string?

(A) 4 m/s.
(B) 0.5 m/s.
(C) 12 m/s.
(D) 2 m/s.
(E) 8 m/s.

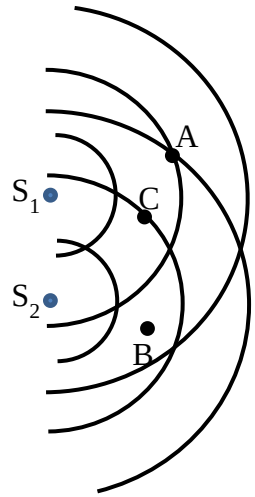
4. You stretch a rubber hose and pluck it. You observe a pulse travel down the hose. What happens to the speed of the pulse if you fill the hose with water without changing anything else?

(A) It increases.
(B) It decreases.
(C) It remains the same.
(D) It will change, but we cannot predict how it will change without more information.

5. The little cross-ridges under the strings of a guitar are called the frets. When you press a string down on a fret you decrease the effective length of the string that can vibrate. Which one of the following changes occurs when you do this?

(A) You change the speed of a wave moving along the string.
(B) You change the fundamental frequency of the vibrating string, but not the fundamental wavelength of waves moving along the string.
(C) You change the fundamental wavelength of the vibrating string, but not the fundamental frequency.
(D) You change both the wavelength and the frequency of waves moving along the string.
(E) You make no change to the fundamental wavelength or frequency of waves moving along the string.

6. The diagram shows the wave crests from two sources of waves that are oscillating in phase with each other (S_1 and S_2). The diagram is a snapshot at one instant in time. What you actually observe however is an interference pattern. At which of the labelled points will there always be destructive interference between the two waves?



(A) Points A and B.
(B) Points B and C.
(C) Point A only.
(D) Point B only.
(E) Point C only.

7. A glass prism separates white light into the colours of the spectrum. Which is the correct reason for this?

(A) It is due to total internal reflection in the prism.
(B) It is due to the interference between different wavelengths of light in the prism.
(C) Light energy is absorbed in the prism.
(D) Light of different frequencies have their frequencies shifted by different amounts depending on the thickness of glass traversed.
(E) Light of different frequencies travel at slightly different speeds in glass.

8. An object is placed between a concave mirror's surface and its focal point. What characteristics does the image formed by the mirror have?

(A) It is real and upright.
(B) It is virtual and upright.
(C) It is real and inverted.
(D) It is virtual and inverted.
(E) No image is formed.

9. A converging lens has a focal length of magnitude *F*. An object is an infinite distance away; that is a very large distance from the lens. What is the location of the image?

(A) At distance *F* from the lens.
(B) At distance ½ *F* from the lens.
(C) At distance 2*F* from the lens.
(D) At a distance greater than 2*F* from the lens.
(E) No image will be formed.

10. A ray of light travelling in a vacuum is incident on a glass plate with index of refraction *n*. What happens to the angle of refraction as the angle of incidence starts from 0° and increases?

(A) It starts from 0° and increases, approaching a limiting value of 90°.
(B) It starts from 0° and increases, approaching a limiting value of θ, where $\sin\theta = \frac{1}{n}$.
(C) It starts from 0° and increases, approaching a limiting value of θ, where $\sin\theta = n$.
(D) It starts from 90° and decreases, approaching a limiting value of 0°.
(E) It starts from 90° and decreases, approaching a limiting value of θ, where $\sin\theta = \frac{1}{n}$.

11. A temperature difference of 9 K corresponds to a temperature difference of about

(A) 5°F
(B) 538°F
(C) 9°F
(D) 16°F
(E) 41°F

12. It is a well-known fact that water has a higher specific heat capacity than iron. Now consider two equal masses of water and iron that are initially in thermal equilibrium. The same amount of heat is added to both. Which statement is true?

(A) The water and iron are still in thermal equilibrium.
(B) They are no longer in thermal equilibrium. The water is at a higher temperature than the iron.
(C) They are no longer in thermal equilibrium. The water is at a lower temperature than the iron.
(D) No statement can be made because there is not enough information given.

13. You are 100 m from a constant-power source of sound that is radiating uniformly in all directions. You hear a sound intensity *I*. You then move toward the sound source until you are a distance of 25 m away from it. What is the sound intensity you hear now?

(A) 16*I*.
(B) 8*I*.
(C) 4*I*.
(D) 2*I*.
(E) *I*.

14. A source of sound emits a frequency of 1000 Hz. You are moving toward this source of sound at a speed that is one-half the speed of sound. What frequency do you hear?

(A) 3000 Hz
(B) 2000 Hz
(C) 1500 Hz
(D) 667 Hz
(E) 500 Hz

15. A car is moving at a constant speed. Consider the following three statements:

1. The car has a constant velocity.
2. The car has zero acceleration.
3. The car is moving in a straight line.

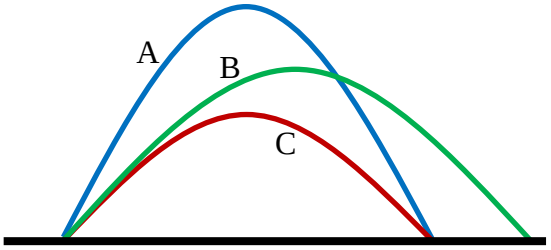
Which of the above statements can we make with certainty?

(A) Only statements 1 and 2.
(B) Only statements 1, 2 and 3.
(C) Only statement 2.
(D) Only statement 1.
(E) None of the above statements can be made with certainty.

16. Two balls are dropped from a building. Ball A is dropped from the top of the building at height h. It is moving with speed v_A just before it hits the ground. Ball B is dropped from a window halfway up the building, from height $\frac{1}{2}h$. Just before it hits the ground its speed is v_B. If we can ignore air resistance, how are these two speeds related?

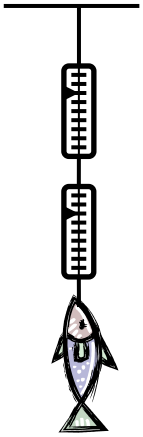
(A) $v_B = 2v_A$
(B) $v_B = \sqrt{2}v_A$
(C) $v_B = \frac{1}{\sqrt{2}}v_A$
(D) $v_B = \frac{1}{2}v_A$
(E) $v_B = \frac{1}{4}v_A$

17. Shown in the diagram are the trajectories of three golf balls that have been hit on a horizontal fairway. Ignoring air resistance, which statement below is correct concerning the time each ball was in the air?



(A) Ball A was in the air for the longest time.
(B) Ball B was in the air for the longest time.
(C) Balls A and C were in the air for the same time, which was shorter than for ball B.
(D) Balls A and C were in the air for the same time, which was longer than for ball B.
(E) We cannot make any statement without knowing the initial speed of each ball.

18. A fish, with weight 10 N, is weighed with two spring scales attached as shown. The scales themselves have negligible weight. Which statement below is correct?



(A) Each scale will read 5 N.
(B) Each scale will read 10 N.
(C) The top scale will read 10 N and the bottom scale will read zero.
(D) The top scale will read zero and the bottom scale will read 10 N.
(E) Each scale will have a different reading, but the sum will be 10 N.

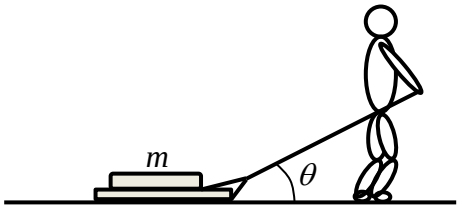
19. A box of mass m is on a frictionless horizontal surface. It is initially at rest. A constant horizontal force is applied to the box for a time t, and the final speed of the box is V. We now repeat the experiment with a second box of mass $2m$. We apply the same force for the same time t. What will be the final speed of the second box?

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

20. You slide a heavy object across a horizontal floor. The work done on the object by the force of gravity is

(A) dependent on how rough the floor is (i.e. on the coefficient of kinetic friction).
(B) dependent on how fast the object is moving.
(C) proportional to the weight of the object.
(D) proportional to the distance the object moves.
(E) zero.

21. A boy is pulling a sled, of mass *m*, along a snow-covered horizontal surface where the coefficient of kinetic friction between the sled and the snow is μ_k. The boy pulls with a rope that make an angle θ with the horizontal surface. The sled moves along the surface at a constant velocity. What must be the tension force in the rope?

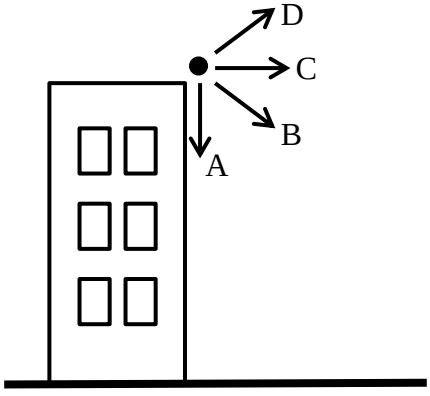


(A) $\dfrac{\mu_k mg}{\cos\theta}$
(B) $\mu_k mg\cos\theta$
(C) $\dfrac{\mu_k mg}{\cos\theta+\mu_k\sin\theta}$
(D) $\dfrac{\mu_k mg}{\cos\theta-\mu_k\sin\theta}$
(E) $\mu_k mg$

22. A truck has double the mass and double the speed of a car. Which statement is true about the truck's kinetic energy compared to that of the car?

(A) The truck has the same kinetic energy as the car.
(B) The truck has twice the kinetic energy of the car.
(C) The truck has four times the kinetic energy of the car.
(D) The truck has eight times the kinetic energy of the car.
(E) The truck has sixteen times the kinetic energy of the car.

23. Four balls are thrown from the the same height from the top of a building. All balls are thrown with the same initial speed. Ball A is thrown straight down. Ball B is thrown at an angle downward. Ball C is thrown horizontally. Ball D is thrown at an angle upward. If we can ignore air resistance, which ball has the highest speed when it reaches the horizontal ground below?



(A) Ball A.
(B) Ball B.
(C) Ball C.
(D) Ball D.
(E) All the balls have the same speed when they reach the ground.

24. Skaters Bob and Alice stand stationary and facing each other in the middle of a frozen pond. Bob has twice the mass of Alice. They push against each other and start moving away from each other. You may ignore friction between their skates and the ice. Which statement below is correct?

(A) After pushing apart they have equal speeds.
(B) After pushing apart they have equal kinetic energies.
(C) As they push apart they both experience the same magnitude net force.
(D) As they push apart the magnitude of the net force experienced by Bob is twice that which Alice experiences.
(E) As they push apart the magnitude of the net force experienced by Alice is twice that which Bob experiences.

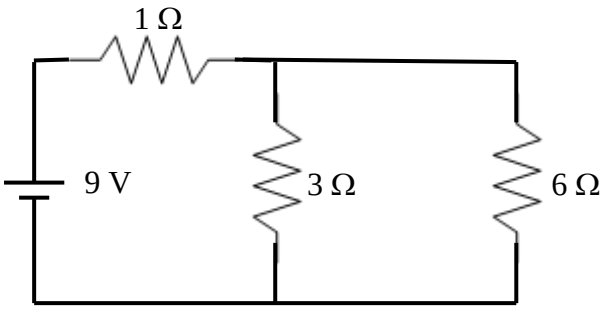
25. Suppose you have two spools of copper wire. The wire on one spool is thicker than the other (i.e. it has a larger diameter). You cut a short length of wire and a long length of wire from each spool. Which piece of wire will have the largest resistance between its ends?

(A) The short, thick wire.
(B) The short, thin wire.
(C) The long, thick wire.
(D) The long, thin wire.
(E) They would all have the same resistance since they are all made of the same material.

26. If the current going through a circuit with a constant resistance is doubled, what happens to the power delivered to the circuit.

(A) It is unchanged.
(B) It is doubled.
(C) It is increased by a factor of 4.
(D) In is increased by a factor of $\sqrt{2}$.
(E) It is increased by a factor of 8.

27. In the circuit shown, the battery may be considered to be an ideal battery. What is the current passing through the 3 Ω resistor?



(A) 1 A
(B) 2 A
(C) 3 A
(D) 4 A
(E) 6 A

28. Nuclei with the same atomic number, but different numbers of neutrons, are referred to as

(A) isotopes.
(B) isotones.
(C) nuclides.
(D) isobars.
(E) nucleons.

29. A radioactive nucleus $^{42}_{21}Sc$ (Scandium) decays, leaving behind the daughter nucleus $^{42}_{20}Ca$ (Calcium). What type of radiation is emitted?

(A) An alpha particle.
(B) A neutron.
(C) A proton.
(D) An electron and an anti-neutrino.
(E) A positron and a neutrino.

30. A ship was floating in fresh water. The same ship now floats in salt water. (Salt water has a higher density than fresh water.) Which statement is correct?

(A) The volume of water displaced by the ship when floating in fresh water is greater than when it is floating in salt water.
(B) The volume of water displaced by the ship when floating in fresh water is less than when it is floating in salt water.
(C) The volume of water displaced by the ship is the same when floating in salt water or fresh water.
(D) The mass of water displaced by the ship when floating in fresh water is greater than when it is floating in salt water.
(E) The mass of water displaced by the ship when floating in fresh water is less than when it is floating in salt water.

31. Suppose you are riding on a merry-go-round near the outside edge. You know that you need to hold on with a certain force to keep from falling off. Now you move toward the centre of the merry-go-round. Other children keep the merry-go-round turning at the same rate. How does the force you need to hold on with change?

(A) The magnitude of the force needed decreases.
(B) The magnitude of the force needed does not change.
(C) The magnitude of the force needed increases.
(D) The magnitude of the force needed is zero if you are not at the outside edge.

32. Satellite A is in a circular orbit around the Earth with radius *R*. Another satellite B is in a circular orbit around the Earth with radius 2*R*. Which statement is correct concerning the magnitude of the acceleration of these orbiting satellites?

(A) The magnitude of the acceleration of satellite A is 4 times that of satellite B.
(B) The magnitude of the acceleration of satellite A is 2 times that satellite B.
(C) The magnitude of the acceleration of satellite A is one half that of satellite B.
(D) The magnitude of the acceleration of satellite A is one quarter that of satellite B.
(E) We cannot answer the question without knowing the masses of the satellites.

END OF EXAMINATION