UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

2010 Saskatchewan High School Physics Scholarship Competition

May 5, 2010 Time: 90 minutes

This competition is based on the Saskatchewan High School Physics Curriculum for Physics 20 and Physics 30.

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. **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 **both** this cover page **and** the OMR sheet must be submitted.
5. All questions are of equal value.
6. 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: _____

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. You measure the length and width of a rectangle arriving at the values 1.944 and 0.544 metres respectively. You calculate the rectangle's area with your calculator and obtain the reading of 1.057536 on its display. Wishing to express the answer to the appropriate number of significant figures, you should record the result as

(A) 1.06 m
(B) 1.060 m
(C) 1.058 m
(D) 1.0575 m
(E) 1.05754 m

2. Compared to the wavelength of a sound which has a frequency of 400 Hz, the wavelength of a sound with frequency 200 Hz is

(A) one quarter as long.
(B) one half as long.
(C) the same length.
(D) two times as long.
(E) four times as long.

3. You are listening to the sound from two loudspeakers which are in two corners of a room. You are somewhere in the interior of the room. The sound from each loudspeaker has the same frequency, *f*, and the same amplitude, *A*. The sound you hear has

(A) frequency *f* and amplitude 2*A*.
(B) frequency *f* and amplitude *A*.
(C) frequency 2*f* and amplitude *A*.
(D) frequency 2*f* and amplitude 2*A*.
(E) frequency *f* and an amplitude that cannot be determined from the information given.

4. When light travels from air into water

(A) its wavelength does not change.
(B) its frequency does not change.
(C) its speed does not change.
(D) All of A, B and C are true.
(E) None of A, B and C are true.

5. A sound of a jackhammer is radiating approximately uniformly in all directions. As you move to double your distance from the jackhammer, what happens to the sound intensity level you hear, as measured in decibels (dB)?

(A) It drops by 2 dB.
(B) It drops by 3 dB.
(C) It drops by 4 dB.
(D) It drops by 6 dB.
(E) It does not change.

6. When a stationary train blows its horn you hear a certain frequency. You are standing at a train station and the train, which is moving at a constant speed, has just passed by and is moving away from you. At that moment, if the train blows its horn, you will hear

(A) a constant frequency that is higher than when the train is stationary.
(B) the same frequency as when the train is stationary.
(C) a constant frequency that is lower than when the train is stationary.
(D) a frequency that is increasing as the train gets further away.
(E) a frequency that is decreasing as the train gets further away.

7. A ray of light, which is travelling in a vacuum, is incident on a glass plate, which has refractive index n, at an angle of incidence zero. As the angle of incidence is increased, what happens to the angle of refraction? [Note: arcsin(x) is the inverse sine function, which is sometimes written asin(x) or $\sin^{-1}(x)$.]

(A) It increases, approaching a maximum value of 90º.
(B) It increases, approaching a maximum value of $\arcsin\left(\frac{1}{n}\right)$.
(C) It increases, approaching a maximum value of $\arcsin(n)$.
(D) It decreases, approaching a minimum value of $\arcsin\left(\frac{1}{n}\right)$.
(E) It decreases, approaching a minimum value of zero.

8. The angle of incidence of light hitting a flat surface

(A) must always equal the angle of reflection.
(B) is always less than the angle of reflection.
(C) is always greater than the angle of reflection.
(D) may be equal to, less than, or greater than the angle of reflection depending on the surface.

9. A light ray, travelling at an angle to a concave mirror's principle axis, crosses that principle axis at the focal point before striking the surface of the mirror. After reflection, this ray

(A) travels parallel to the mirror's surface.
(B) travels perpendicular to the principle axis.
(C) travels parallel to the principle axis.
(D) travels at an angle so that it once again crosses the principle axis at the focal point.
(E) travels at an angle so that it crosses the principle axis at a point different from the focal point.

10. A convex mirror has a focal length *f*. An object is placed on the principle axis at a distance from the mirror which between *f* and 2*f*. The image is located

(A) behind the mirror's surface and it is smaller than the object.
(B) behind the mirror's surface and it is larger than the object.
(C) in front of the mirror, and it is smaller than the object.
(D) in front of the mirror, and it is larger than the object.
(E) No image is formed.

11. A thermally isolated system is initially made up of a hot piece of aluminum and a cold piece of copper. The aluminum and copper are in thermal contact. The specific heat capacity of aluminum is more than double that of copper. Which object experiences the greater magnitude gain or loss of heat during the time the system takes to come to thermal equilibrium?

(A) The aluminum.
(B) The copper.
(C) Neither, both experience the same magnitude heat gain or loss.
(D) The answer depends on the final temperature of the system.
(E) The answer depends on the masses of aluminum and copper involved.

12. Which of the following <u>best</u> explains why sweating is important to humans in maintaining a suitable body temperature during hot weather?

(A) Moisture on the skin increases thermal conductivity, thereby allowing heat to flow out of the body more effectively.
(B) Evaporation of moisture from the skin extracts heat from the body.
(C) The high specific heat of water on the skin absorbs heat from the body.
(D) The sweat glands push heat out of the body with the moisture.
(E) The moisture in the sweat is naturally cooler than the body.

13. A car drives 6 km in 2 minutes and then drives an additional 8 km in 4 minutes. What is the approximate average speed of the car for the whole trip?

(A) 2.0 km/minute.
(B) 2.3 km/minute.
(C) 2.5 km/minute.
(D) 5.0 km/minute.
(E) 6.0 km/minute.

14. A rock is thrown vertically downward from the top of a tall cliff. If we can ignore the effects of air resistance, the acceleration of the rock after it was thrown but before it hits the ground

(A) is zero.
(B) has magnitude greater than zero but less than g.
(C) has magnitude equal to g.
(D) has magnitude greater than g.
(E) cannot be determined without knowing how hard the rock was thrown.

15. A student asks "Is it possible for an object to have an acceleration which points in the opposite direction to its velocity?" What would be the best answer to this question?

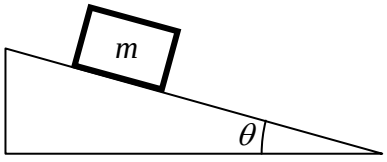
(A) No, this is not possible since velocity and acceleration are always parallel vectors.
(B) No, this is not possible since in more than one dimension velocity and acceleration vectors are always perpendicular.
(C) Yes, this is possible, and an example would be that of a falling object.
(D) Yes, this is possible, and an example would be that of a car driving in a circle.
(E) Yes, this is possible, and an example would be that of a stone thrown upward.

16. Two men push on opposite sides of a packing crate. Friction between the crate and the floor is negligible. The two men each push horizontally with a force of magnitude 200 N. Under these circumstances we can say that the magnitude of the net force acting on the crate in the horizontal direction is

(A) zero.
(B) 100 N.
(C) 200 N.
(D) 400 N.
(E) not possible to determine without knowing if the crate is moving or not.

17. A block of ice of mass m is placed on a ramp which is at an angle θ to the horizontal as shown. We can ignore friction between the ice and the ramp. What is the magnitude of the acceleration of the block of ice?

(A) $mg\sin\theta$
(B) $\frac{g}{m}\sin\theta$
(C) $g\cos\theta$
(D) $g\sin\theta$
(E) g



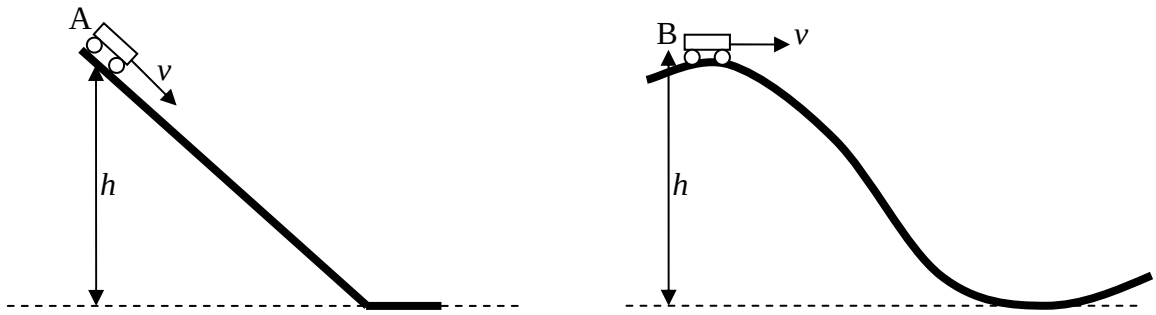
18. Abe and Ben move identical boxes equal distances in a horizontal direction. Abe slides the box along the floor, where we can ignore friction between the box and the floor. Ben picks up the box, carries it the distance, and then sets it down. Compare the total amount of work done by Abe and Ben in moving the boxes.

(A) Abe does less work than Ben.
(B) Ben does less work than Abe.
(C) Neither Abe nor Ben do any work.
(D) The amount of work done by each depends on the time they take.
(E) There is not enough information given to determine an answer.

19. A car, with a mass m, is moving East with a speed v. A van, with mass $2m$, is moving West also with a speed v. The car has kinetic energy K. The kinetic energy of the van is

(A) $-K$
(B) $-2K$
(C) K
(D) $2K$
(E) $4K$

20. Two roller coaster cars are each moving with speed v when they are at the top of the hills shown in the diagram. The bottoms of both hills are at a height h below the tops. We can ignore the effects of friction. Compare the speed of car A when it reaches the bottom of its hill to the speed of car B when it reaches the bottom of its hill. Which statement is correct?



(A) Car A will be moving faster than car B.
(B) Car B will be moving faster than car A.
(C) Both cars will have the same final speeds.
(D) We need more information to decide which car will have the larger final speed.

21. A golf ball, travelling 3 m/s to the right collides head-on with a stationary bowling ball. We can ignore friction during the short time of the collision which we can consider to be almost perfectly elastic. The speed of the golf ball immediately after the collision is

(A) slightly less than 3 m/s.
(B) slightly greater than 3 m/s.
(C) equal to 3 m/s.
(D) very close to zero.
(E) zero.

22. A ball that is moving horizontally strikes a vertical wall and bounces back with the same speed with which it hits the wall. For a given collision time (the time for which the ball is in contact with the wall) the average force exerted on the wall by the ball is primarily determined by

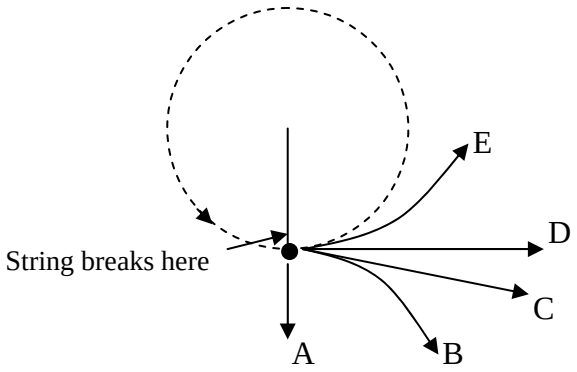
(A) the kinetic energy of the ball.
(B) the force carried by the ball.
(C) the momentum of the ball.
(D) the mass of the ball.
(E) the mass of the wall.

23. A boy and a girl are riding on a merry-go-round. The girl is sitting near the outer rim of the merry-go-round while the boy is nearer to the axis of rotation. The merry-go-round is turning at a constant rate. How do the accelerations of the boy and girl compare?

(A) The boy has a greater magnitude acceleration than the girl.
(B) The boy and girl have the same magnitude acceleration.
(C) The girl has a greater magnitude acceleration than the boy.
(D) The boy and girl both have zero acceleration.
(E) The answer depends of the relative masses of the boy and girl.

24. A girl attaches a rock to a string which she then swings in a horizontal circle. The string breaks. What will be the path of the rock after the string breaks? The figure shows a view from above.

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



25. A 4 kg object, moving horizontally across the floor, has an initial kinetic energy of 10 J. How far will it slide across the surface if the friction force acting on the object remains constant at 0.50 N?

(A) 5 m.
(B) 10 m.
(C) 20 m.
(D) 40 m.
(E) The distance cannot be determined from the information given.

26. When the atmospheric pressure increases, the pressure at the bottom of a lake

(A) increases by the same amount as the atmospheric pressure change.
(B) increases by a greater amount than the atmospheric pressure change.
(C) increases by a smaller amount than the atmospheric pressure change.
(D) does not change.
(E) changes, but how it changes depends on depth of the lake.

27. An object, with a weight of 100 N, floats of the surface of water with three-quarters of its volume submerged below the surface. What is the buoyant force acting on the object?

(A) 25 N.
(B) 50 N.
(C) 75 N.
(D) 100 N.
(E) None of the above.

28. Two or more resisters are connected in parallel to a battery. Consider the following statements about this situation

a. The potential difference across each resistor is the same.
b. The total potential across the combination is the algebraic sum of the potentials across the individual resistors.
c. The same current flows through each resistor.
d. The total current flowing from the battery equals the sum of the currents flowing through each resistor.

Which statements are correct?

(A) Statements a and b.
(B) Statements a and d.
(C) Statements b and c.
(D) Statements b and d.
(E) Statements a, b and d.

29. Suppose that two isolated charges attract each other with a force of magnitude *F*. If the separation between these charges was made half as large, each charge would then experience a force

(A) *F*.
(B) ½ *F*.
(C) ¼ *F*.
(D) 2 *F*.
(E) 4 *F*.

30. Copper wire which is labelled AWG-7 has a cross-sectional area which is double the cross-sectional area of wire labelled AWG-10. An electrician cuts off a short and a long piece of AWG-7 wire and also cuts off a short and a long piece of AWG-10 wire. Which piece of wire has the largest resistance?

(A) The long piece of AWG-7 wire.
(B) The short piece of AWG-7 wire.
(C) The long piece of AWG-10 wire.
(D) The short piece of AWG-10 wire.
(E) The pieces would all have the same resistance.

31. What is the missing particle in the nuclear fission reaction

$$^{235}_{92}\mathrm{U} + n \rightarrow ^{140}_{54}\mathrm{Xe} + ^{94}_{38}\mathrm{Sr} + n + ?$$

(A) A proton.
(B) A neutron.
(C) An electron.
(D) A positron.
(E) An alpha-particle.

32. The half-life of a particular radioactive isotope is $T_{½}$. This means that

(A) after a time $T_{½}$ only 25% of the original number of radioactive nuclei remain.
(B) after a time $T_{½}$ only 0.5% of the original number of radioactive nuclei remain.
(C) after a time $T_{½}$ the rate of radioactive decays is one-half of the original radioactive decay rate.
(D) after a time $T_{½}$ the rate of radioactive decays is zero.
(E) after a time $T_{½}$ there will be no radioactive nuclei left.

END OF EXAMINATION