UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

2008 Saskatchewan High School Physics Scholarship Competition

May 7, 2008 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 7 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: _____

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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. Which one of the following is a quantity that is **NOT** given to 4 significant figures?

(A) 0.0145 m
(B) $2.998 \times 10^{+6}$ m/s
(C) 0.003380 s
(D) 12.67×10^{-5} μm
(E) 7801 km

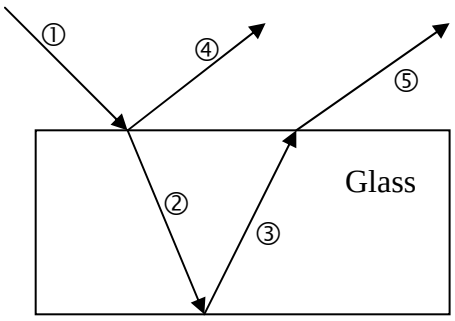
2. If the frequency of a wave travelling along a stretched string is doubled

(A) the wavelength is doubled.
(B) the wavelength is halved.
(C) the speed of the wave is doubled.
(D) the speed of the wave is halved.
(E) more than one of the above statements are true.

3. It is known that as the temperature of the air increases the speed of sound in the air increases. Balboa Park in San Diego has an outdoor pipe organ. What happens to the fundamental frequency of one of the organ pipes as the day gets hotter? (Assume that the expansion of the organ pipe itself is negligible.)

(A) It stays the same.
(B) It decreases.
(C) It increases.
(D) Whether it increases or decreases depends on the original pitch of the organ pipe.

4. In the diagram the light ray labelled 1 travels in air and hits a block of glass with parallel sides. Which one of the following statements is **not** true.



(A) The angle of incidence of ray 1 is the same as the angle of refraction of ray 5.
(B) The angle of reflection of ray 4 is the same as the angle of refraction of ray 2.
(C) The angle of reflection of ray 4 is the same as the angle of refraction of ray 5.
(D) Rays 2 and 3 travel the same distance in the glass.
(E) Ray 4 is parallel to ray 5.

5. A guitar string (which is fixed at both ends) is vibrating at a resonant frequency f such that there are 3 antinodes between the ends of the string. The resonant frequency that will have 4 antinodes will have frequency

(A) $\frac{3}{4} f$
(B) $\frac{4}{3} f$
(C) $\frac{2}{3} f$
(D) $\frac{3}{2} f$
(E) $\frac{5}{4} f$

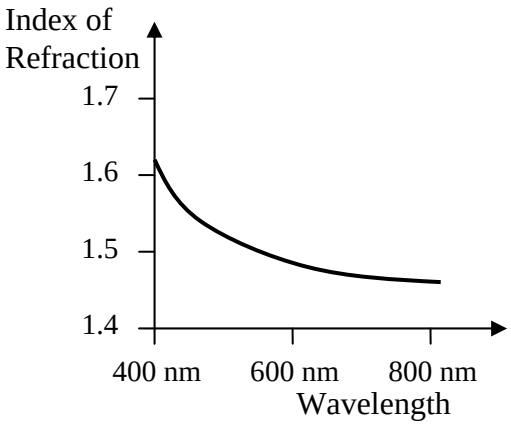
6. Light passes through a narrow slit and it is seen to spread out so that on a screen behind the slit there is a central board band of bright light. Which one of the following changes will make that band of light on the screen wider?

(A) Move the screen closer to the slit.
(B) Use light of smaller wavelength.
(C) Make the slit narrower.
(D) Increase the frequency of the light.
(E) None of the above, all will make the band smaller.

7. A candle is placed on the principal axis of a concave mirror at a distance of 10 cm from the mirror. The focal length of the mirror is 20 cm. The image formed by the mirror will be

(A) real, upright and enlarged.
(B) virtual, upright and enlarged.
(C) real, inverted and enlarged
(D) virtual, inverted and smaller.
(E) virtual, upright and smaller.

8. In a certain type of glass the index of refraction as a function of wavelength is shown in the diagram. Which colour of light will undergo the greatest change in direction when passing from air into glass of this type?



(A) Red.
(B) Yellow.
(C) Green.
(D) Blue.
(E) Violet.

9. A ray of light travelling parallel to the principal axis of a diverging thin lens strikes the lens at a point that is a bit to the side of the centre of the lens. After passing through the lens this ray

(A) travels so that it never crosses the principal axis of the lens.
(B) travels so that it crosses the principal axis at a focal point.
(C) travels so that it crosses the principal axis at a point between the lens and a focal point.
(D) travels so that it crosses the principal axis at a point that is not between the lens and a focal point.
(E) travels parallel to the principal axis.

10. Some refractive indexes are: Air 1.0003; Water 1.333; Ice 1.309; Crown glass 1.52; Flint Glass 1.66; Diamond 2.42. Which one of the following cases **cannot** produce total internal reflection? A light ray that goes from

(A) water to air.
(B) water to ice.
(C) flint glass to crown glass.
(D) diamond to water.
(E) flint glass to diamond.

11. A piece of copper has the same mass as a piece of aluminum. It is known that the specific heat capacity of aluminum is more than double that of copper. The copper is hot and the aluminum is cold. The two pieces are brought into thermal contact with each other and they are thermally isolated from their surroundings. Which object experiences the greater temperature change during the time that they take to reach thermal equilibrium?

(A) The aluminum.
(B) The copper.
(C) Neither, both experience the same size temperature change.
(D) It is impossible to tell without more information.

12. When a quantity of water vapour condenses,

(A) the temperature of the quantity increases.
(B) the temperature of the quantity decreases.
(C) heat energy leaves the quantity.
(D) heat energy enters the quantity.
(E) More than one of the above statements are correct.

13. Which one of the following statements concerning scalars and vectors is **FALSE**?

(A) A vector quantity deals with magnitude and direction.
(B) The direction of an arrow representing a vector gives the direction of the vector.
(C) The length of an arrow representing a vector is proportional to the magnitude of the vector.
(D) A scalar quantity can never be negative.
(E) A scalar quantity does not include a direction.

14. A ball is thrown straight up. For which point during its flight are **both** the instantaneous acceleration equal to zero **and** the instantaneous velocity equal to zero?

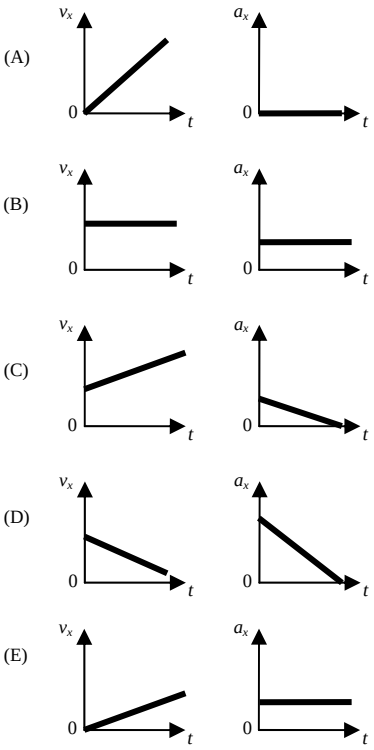
(A) On the way up.
(B) On the way down.
(C) At the highest point in its flight.
(D) At the highest point in its flight, but only if we neglect air resistance.
(E) There is no point during its flight where both are zero.

15. Two stones are launched from the top of a tall building; one stone is thrown directly upward with a speed of 20 m/s and the other is thrown directly downward with the same speed. If we neglect air resistance, how do their speeds as they hit the street below compare?

(A) The one thrown upward is travelling faster.
(B) The one thrown downward is travelling faster.
(C) Both hit the street with the same speed.
(D) It is impossible to tell without knowing which stone is heavier.
(E) It is impossible to tell without knowing if the building is higher than half the maximum height reached by the stone thrown upward.

16. An object is moving along the *x*-axis. The diagram at right shows five pairs of graphs with a velocity versus time graph and a corresponding acceleration versus time graph next to it. For which pair of graphs is the acceleration versus time graph consistent with the corresponding velocity versus time graph?

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



17. On two consecutive pitches the batters hit fly balls that are caught. The first is caught by a player standing on second base and the second is caught by a player in the far outfield. Both balls reached the same height. If we neglect air friction we can deduce that

(A) both balls left the bat with the same speed.
(B) both balls were in the air for the same amount of time.
(C) both balls left the bat at the same angle above the horizontal.
(D) the ball caught by the second base man left the bat with the higher speed.
(E) the ball caught by the outfielder was in the air for the longer time.

18. Which one of the following is a true statement?

(A) Mass and Weight are the same thing measured in different units.
(B) When an object is in free fall (with no air resistance), it is massless.
(C) If the mass of an object on Earth is doubled its weight is not necessarily also doubled.
(D) The mass of an object is independent of the force of gravity acting on the object.
(E) The mass of an object on the Moon's surface is less than its mass on the Earth's surface.

19. A mass *m* is released from rest from a height *h* above the ground. Ignore any frictional effects. Which one of the following statements is correct?

(A) The speed of the mass when it strikes the ground is directly proportional to *h*.
(B) The speed of the mass when it strikes the ground is inversely proportional to *h*.
(C) The speed of the mass when it strikes the ground is directly proportional to *m*.
(D) The kinetic energy of the mass when it strikes the ground is directly proportional to *h*.
(E) The kinetic energy of the mass when it strikes the ground is inversely proportional to *m*.

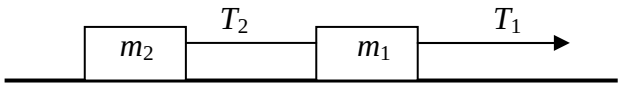
20. A small car collides head-on with a large truck. Which one of the following statements is correct?

(A) The small car experiences the greater magnitude average force during the collision.
(B) The large truck experiences the greater magnitude average force during the collision.
(C) The magnitude of the momentum change of the small car is greater than that of the large truck.
(D) We cannot make any statement about the average force or the momentum change since the masses and velocities are not given.
(E) The small car and the large truck experience the same magnitude average force and the same magnitude momentum change during the collision.

21. An object of mass *m*, initially at rest, is lifted by you to a height *h* and then returned to its original position where it is again at rest. Ignoring friction, which one of the following statements is correct for this complete motion.

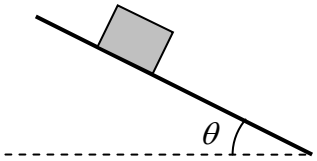
(A) The work done by the lifting force is $2mgh$.
(B) The work done by gravity is $-2mgh$.
(C) The work done by gravity is zero.
(D) The work done by gravity is mgh.
(E) The work done by the lifting force is $-mgh$.

22. Two blocks, of masses m_1 and m_2, are tied together and pulled by a constant horizontal force, T_1 as shown. The horizontal surface on which they slide is frictionless. The acceleration of the blocks has magnitude *a*. The tension T_2 in the string connecting the two blocks is



(A) $m_2 a$
(B) $(m_1 - m_2)a$
(C) $m_1 a$
(D) $(m_1 + m_2)a$
(E) $(m_2 - m_1)a$

23. A box, of mass *m*, is at rest on a ramp inclined at an angle θ to the horizontal as shown. The static friction force on the box is



(A) $mg\sin\theta$ directed up the ramp and parallel to the ramp's surface.
(B) $mg\sin\theta$ directed horizontally to the left.
(C) $mg\cos\theta$ directed up the ramp and parallel to the ramp's surface.
(D) $mg\cos\theta$ directed perpendicular to the ramp.
(E) zero, since the box is stationary.

24. An object of mass *m* moves with kinetic energy *K*. The object has momentum of magnitude

(A) $\dfrac{K}{2m}$
(B) $\sqrt{\dfrac{K}{2m}}$
(C) $2mK$
(D) $2m\sqrt{K}$
(E) $\sqrt{2mK}$

25. Two masses, one with mass *m* and the other with mass $2m$, initially at rest, are each acted on by a constant net force with magnitude *F* while each mass moves a distance *d*. At the end of the distance *d*

(A) the mass $2m$ has twice the kinetic energy of the mass *m*.
(B) the mass $2m$ has one-half the kinetic energy of the mass *m*.
(C) the mass $2m$ has the same kinetic energy as the mass *m*.
(D) the mass $2m$ has the same momentum as the mass *m*.
(E) the mass $2m$ has the same speed as the mass *m*.

26. Compared to yesterday you did three times the work in one-third the time. To do so, your power output must have been

(A) the same as yesterday's power output.
(B) one-third yesterday's power output.
(C) three times yesterday's power output.
(D) one ninth yesterday's power output.
(E) nine times yesterday's power output.

27. At a height above the Earths surface equal to the radius of the Earth (i.e. at a distance 2 times the radius of the Earth from the centre of the Earth), the acceleration due to gravity will be

(A) g
(B) $2g$
(C) $\frac{1}{2}g$
(D) $\frac{1}{4}g$
(E) $\frac{1}{8}g$

28. A toy airplane is travelling in a horizontal circle at a constant speed at the end of a tether wire. The magnitude of the tension in the wire in this situation is F. The wire is played out until it is twice its original length and the plane is made to fly at twice its original speed. The tension in the wire is now

(A) ¼F
(B) ½F
(C) F
(D) 2F
(E) 4F

29. Two resistors, one with resistance R and the other with resistance 2R are connected in series with a battery. The current passing through the resistance 2R is

(A) 4 times the current passing through the resistance R.
(B) 2 times the current passing through the resistance R.
(C) the same as the current passing through the resistance R.
(D) one half the current passing through the resistance R.
(E) one quarter the current passing through the resistance R.

30. An ideal 10 V battery is connected to a 5 Ω resistor. The power being supplied by the battery is

(A) 50 W (B) 100 W (C) 2 W (D) 25 W (E) 20 W

31. The neutral atom of the isotope of Uranium, $^{238}_{92}\mathrm{U}$, contains 92 electrons. Which statement is correct?

(A) The nucleus contains 92 protons and 238 neutrons.
(B) The nucleus contains 238 protons and 92 neutrons.
(C) The nucleus contains 146 protons and 92 neutrons.
(D) The nucleus contains 92 protons and 146 neutrons.
(E) The nucleus contains 330 protons and neutrons.

END OF EXAMINATION