UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

Saskatchewan High School Physics Scholarship Competition

May 9, 2007 Time: 90 minutes

This competition is based on the Saskatchewan High School Physics Core 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 8 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.

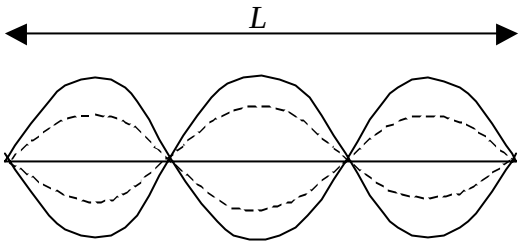
1. How many times larger than a micrometer is a kilometre? It is

(A) one thousand times larger.
(B) ten thousand times larger.
(C) one million times larger.
(D) one hundred million times larger.
(E) one billion times larger.

2. A girl on a beach watching water waves see 4 waves pass by in 2 seconds, each with a wavelength of 0.5 m. The speed of the waves is

(A) 0.25 m/s.
(B) 0.5 m/s.
(C) 1.0 m/s.
(D) 2.0 m/s.
(E) 4.0 m/s.

3. A guitar string has a length *L* and is fixed at both ends. It is made to vibrate with the standing wave pattern shown in the diagram. If the speed of the wave travelling along the string is *v*, the frequency of the vibration is



(A) $f = \frac{v}{2L}$

(B) $f = \frac{v}{3L}$

(C) $f = \frac{3v}{2L}$

(D) $f = \frac{3L}{2v}$

(E) $f = \frac{3L}{v}$

4. Which one of the following is **not** an electromagnetic wave?

(A) X-rays
(B) Visible light
(C) FM radio waves
(D) Sound waves
(E) Ultraviolet rays

5. A sound wave is resonating in a pipe that is closed at one end and open at the other end. Which one of the following statements is true concerning the oscillation of the displacement of the air molecules in the pipe?

(A) Nodes are formed at both ends of the pipe.
(B) Antinodes are formed at both ends of the pipe.
(C) An antinode is formed at the closed end of the pipe and a node is formed at the open end.
(D) A node is formed at the closed end of the pipe and an antinode is formed at the open end.
(E) A sound wave cannot resonate in a pipe that is closed at only one end.

6. A single convex (diverging) mirror, with focal length of magnitude F, forms an image which is

(A) always virtual.
(B) always real.
(C) virtual only if the object distance is greater than F, otherwise real.
(D) virtual only if the object distance is less than F, otherwise real.
(E) virtual only if the object distance is less than $2F$, otherwise real.

7. When a ray of light travelling in one medium strikes an interface with another medium the angle of refraction

(A) is always equal to the angle of incidence.
(B) is always greater than the angle of incidence.
(C) is always less than the angle of incidence.
(D) may be greater, less than, or equal to the angle of incidence.

8. The critical angle for a water-air interface is 48.8°. This means that light travelling from within air and striking a water-air interface with an incident angle greater than 48.8° will be

(A) absorbed.
(B) partially reflected and partially transmitted with an angle of refraction greater than the incident angle.
(C) partially reflected and partially transmitted with an angle of refraction less than the incident angle.
(D) totally transmitted with an angle of refraction greater that 48.8°.
(E) totally reflected.

9. A beam of light passes from air into glass, which has an index of refraction of 1.50. Which one of the following is true?

(A) Its frequency increases by a factor of $\frac{3}{2}$.
(B) Its frequency decreases by a factor of $\frac{2}{3}$.
(C) Its speed increases by a factor of $\frac{3}{2}$.
(D) Its speed decreases by a factor of $\frac{2}{3}$.
(E) Its wavelength is unchanged.

10. For a particular type of glass, red light has a refractive index of 1.520 and blue light has a refractve index of 1.531. A converging lens is made from this glass. Which one of the following statements is true?

(A) The focal length of this lens is greater for blue light than it is for red light.
(B) The focal length of this lens is greater for red light than it is for blue light.
(C) The focal length of this lens is the same for red and blue light.
(D) Although the focal length for red and blue light will be different, it is not possible to say which is greater without more information.
(E) A red object placed in front of the lens will form an image, but a blue object will not form an image since its light will be scattered in all directions.

11. The average kinetic energy of the molecules in a substance is most closely associated with

(A) heat
(B) expansion.
(C) weight.
(D) temperature.
(E) absolute zero.

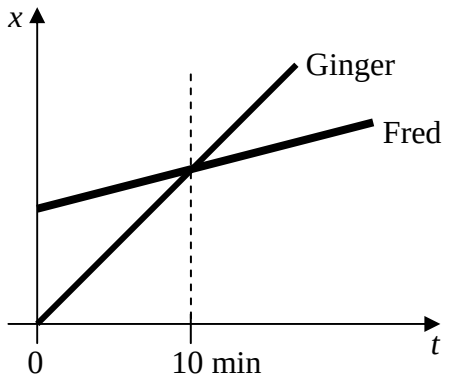
12. As water boils, the heat transfer through the water is best described as

(A) convection.
(B) conduction.
(C) radiation.
(D) insulation.
(E) temperature.

13. The resultant of the two displacement vectors, 30 km East, and, 40 km South, is

(A) a displacement with magnitude 10 km, in a direction between East and South.
(B) a displacement with magnitude 10 km, in a direction between East and North.
(C) a displacement with magnitude 70 km, in a direction between East and North.
(D) a displacement with magnitude 70 km, in a direction between East and South.
(E) a displacement with magnitude 50 km, in a direction between East and South.

14. Two cyclists, Fred and Ginger, are travelling along a straight road. Let x be the distance along the road from a town. The figure shows their positions as a function of time. At the time t = 10 min



(A) Fred is moving faster than Ginger and Fred is accelerating.
(B) Ginger is moving faster than Fred and Ginger is accelerating.
(C) Both are moving at the same speed and neither is accelerating.
(D) Fred is moving faster than Ginger and both are accelerating.
(E) Ginger is moving faster than Fred and neither is accelerating.

15. A football player starts from rest 10 m away from the goal line and accelerates away from the goal line at 5 m/s^2. How far away from the goal line is the player after 4 seconds?

(A) 6 m.
(B) 30 m.
(C) 40 m.
(D) 50 m.
(E) 60 m.

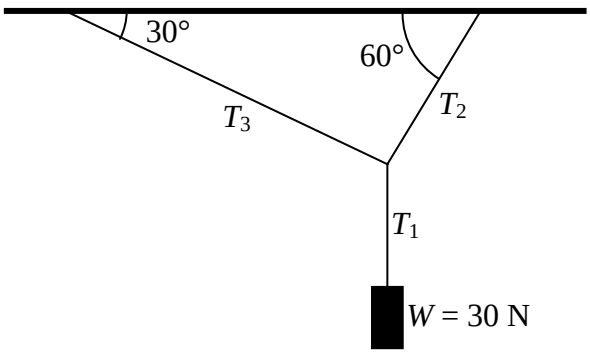
16. Which one of the following statements is ***NOT*** true of a projectile launched at an angle to the horizontal ground (ignoring friction with the air)?

(A) The horizontal velocity is constant.
(B) The vertical acceleration is upward during the first half of the flight, and downward during the second half of the flight.
(C) The horizontal acceleration is zero.
(D) The vertical acceleration is constant.
(E) The time of the flight of the projectile can be found by dividing the horizontal distance by the horizontal velocity.

17. The amount of force needed to keep a hockey puck, of mass m, moving at a constant speed, v, across a horizontal frictionless ice surface is

(A) zero
(B) mg
(C) mv
(D) $\frac{1}{2}mv^2$
(E) $\dfrac{mv}{g}$

18. Consider the weight of 30 N which is suspended from the roof by light strings as shown. T_1, T_2 and T_3 are the magnitudes of the tensions in the strings as labelled. Which one of the following statements is true?



(A) T_1 must be greater than 30 N.
(B) $T_3^2 = T_1^2 + T_2^2$
(C) $T_1 = T_2 + T_3$
(D) $T_1 = T_2 \sin 60° - T_3 \sin 30°$
(E) $T_3 \cos 30° = T_2 \cos 60°$

19. A 10 kg mass and a 4 kg mass are each acted on by a force of the same magnitude (which remains constant) for the same period of time. Both masses are at rest before the forces are applied. The 10 kg mass moves a distance x_1 and the 4 kg mass moves a distance x_2 due to the action of the forces during this time period. Which one of the following statements is true?

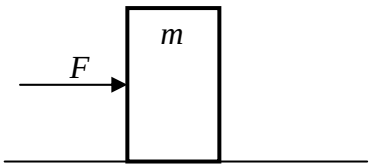
(A) $x_2 = x_1$
(B) $x_2 = \frac{5}{2} x_1$
(C) $x_2 = \frac{2}{5} x_1$
(D) $x_2 = \left(\frac{2}{5}\right)^2 x_1$
(E) $x_2 = \left(\frac{5}{2}\right)^2 x_1$

20. One statement of Newton's third law is "For every action there is an equal and opposite reaction." Consider an apple, with weight *W*, falling from a tree. If the "action" force is the weight force on the apple, what is the "reaction" force.

(A) There is no reaction force in this case since the apple is not touching anything else.
(B) It is the force of impact when the apple hits the ground.
(C) It is the air friction pushing up on the apple as it falls.
(D) It is the apple pulling upward on the Earth with force *W*.
(E) It is the Earth pulling down on the apple with force *W*.

21. You are trying to move a refrigerator, with mass *m*, across the floor. You push horizontally on the side of the fridge with a force of magnitude *F*, but the fridge still does not move. The coefficient of static friction between the fridge and the floor is μ_s. When you are pushing with the force *F* the magnitude of the force of static friction f_s between the fridge and the floor must be

(A) $f_s = F$
(B) $f_s = mg$
(C) $f_s = \mu_s F$
(D) $f_s = \mu_s mg$
(E) $f_s = \mu_s (mg + F)$



22. Two equal mass objects, A and B, are taken to the top of a tall tower. Object A is lifted straight up by a crane and object B is carried up more slowly along a stairway that encircles the tower's perimeter. Compare the change in gravitational potential energy experienced by the two objects.

(A) Object A had a greater potential energy change because it got to the top faster.
(B) Object B had a greater potential energy change because it travelled a greater distance to get to the top.
(C) Both objects experienced the same gravitational potential energy change.
(D) It is impossible to tell since times and distances are not given.

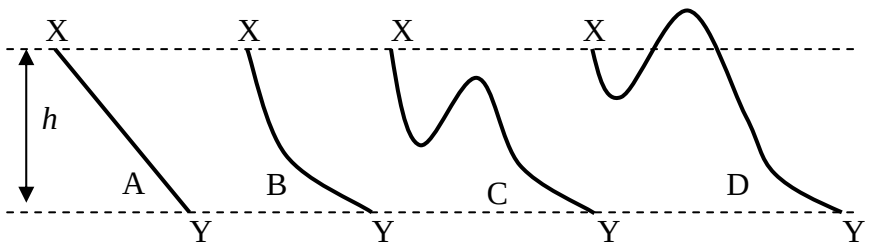
23. You slam on the brakes of your car in a panic, locking the wheels, so that you slide a certain distance before coming to rest. If you had been travelling twice as fast, what distance would your car have skidded under the same conditions?

(A) It would have skidded 8 times further.
(B) It would have skidded 4 times further.
(C) It would have skidded 2 times further.
(D) It would have skidded $\sqrt{2}$ times further.
(E) It is impossible to tell from the information given.

24. A constant horizontal force, of magnitude *F*, acts on an object of mass *m* for a time *t* in a friction free environment. During that time the object moves a distance *d*. The change in the object's momentum is

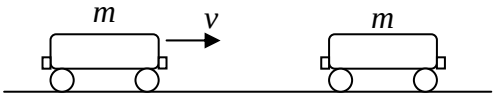
(A) Ft
(B) Fd
(C) $\frac{Ft}{m}$
(D) $\frac{Fd}{m}$
(E) $\sqrt{\frac{2Fd}{m}}$

25. A roller-coaster car moves with no friction on each of the tracks shown. The car starts from rest at point X in each case. The point Y is the same vertical distance below the point X in each case. The speed of the car when it reaches point Y will be



(A) greatest for track A.
(B) the same for all tracks A, B, C and D.
(C) the same for tracks B, C and D but not A.
(D) the same for tracks A and B, but the car will never reach point Y for tracks C and D.
(E) the same for tracks A, B and C, but the car will never reach point Y for track D.

26. A cart with mass *m* is moving on a horizontal frictionless surface with speed *v*. It collides with another stationary cart, also with mass *m*, and the couplings on the carts cause them to stick together after the collision. What is the total kinetic energy of two carts just after the collision?

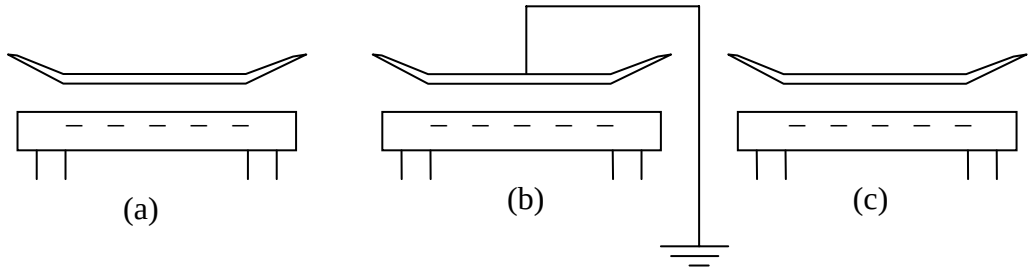


(A) zero
(B) $\frac{1}{2}mv^2$
(C) mv^2
(D) $\frac{1}{4}mv^2$
(E) $2mv^2$

27. Three metal objects are brought near to each other two at a time. When object A is brought near object B, they repel. When object B is brought near object C, they also repel. Which one of the following statements is true?

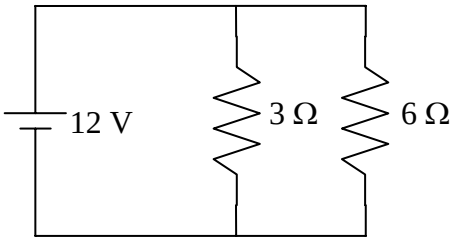
(A) Objects A and C possess charges of the same sign which is opposite to the charge on B.
(B) Objects A and C possess charges of opposite sign.
(C) All three objects possess charges of the same sign.
(D) One of the objects has no charge.
(E) More experiments would be necessary to determine which of the above statements is correct.

28. The surface of an ebony table is rubbed with some fur leaving a net negative charge on the surface of the table. An uncharged metal plate, which is handled with insulating gloves, is brought near to, but not touching, the table surface; diagram (a). Then a wire, connected to ground, is touched to the top surface of the plate; diagram (b). The wire is now removed; diagram (c), and finally the plate is then taken well away from the table.



The plate
(A) now has a net positive charge.
(B) is still uncharged.
(C) now has a net negative charge.
(D) now has a net charge of zero but has a positive charge on its top and a negative charge on its bottom.
(E) now has a net charge of zero but has a negative charge on its top and a positive charge on its bottom.

29. This question and the following one refer to the circuit pictured. The 12 V battery may be considered to be ideal.



What is the current flowing out of the battery?
(A) $\frac{3}{4}$ A
(B) $\frac{4}{3}$ A
(C) 2 A
(D) 4 A
(E) 6 A

30. What is the power being delivered to the 3 Ω resistor?

(A) 12 W (B) 24 W (C) 48 W (D) 72 W (E) 108 W

END OF EXAMINATION