UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

Saskatchewan High School Physics Scholarship Competition

May 3, 2006 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 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: _____

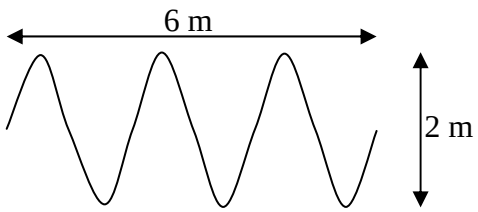
FOR EACH OF THE FOLLOWING QUESTIONS ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

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

1. Which one of the following numbers is correctly expressed in scientific notation to 4 significant figures

(A) 0.03829 s
(B) 78.3×10^3 km
(C) 6.856×10^9 kg
(D) 299.05 m/s
(E) 2.1×10^{-5} s

2. The diagram shows a snapshot of a wave at an instant in time. This wave has



(A) amplitude 2 m and wavelength 2 m.
(B) amplitude 1 m and wavelength 2 m.
(C) amplitude 2 m and wavelength 3 m.
(D) amplitude 2 m and wavelength 6 m.
(E) amplitude 1 m and wavelength 3 m.

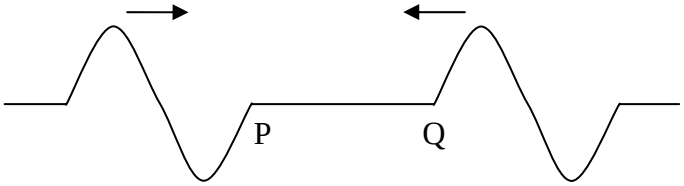
3. A string is stretched with a fixed tension in it. When one end of the string is wiggled at a frequency *f*, the wave that travels down the string has speed *v* and wavelength λ. If instead the end of the string is wiggled with frequency 2*f* the wave that travels down the string will have

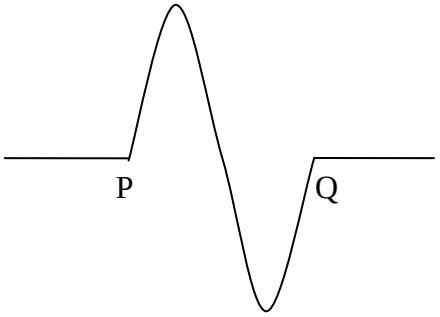
(A) speed 2*v* and wavelength λ.
(B) speed *v* and wavelength 2λ.
(C) speed 2*v* and wavelength $\frac{1}{2}\lambda$.
(D) speed *v* and wavelength $\frac{1}{2}\lambda$.
(E) speed $\frac{1}{2}v$ and wavelength λ.

4. Which of the following lists electromagnetic waves from longest wavelength to shortest wavelength?

(A) X-ray, ultraviolet, visible light.
(B) visible light, ultraviolet, microwaves.
(C) Infrared, visible light, X-rays.
(D) radio waves, X-rays, visible light.
(E) ultraviolet, visible light, infrared.

5. The diagram on the right shows two wave pulses moving toward each other in a string at one instant in time. Which of the following diagrams best represents the shape of the string at a later instant in time when the two wave pulses are both between points P and Q?



(A)


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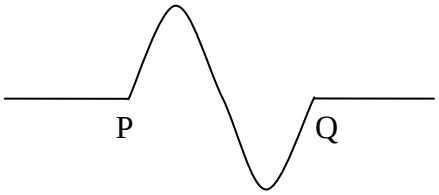

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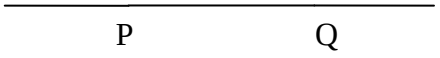

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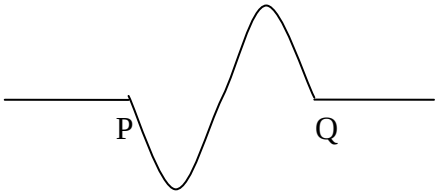


(E) None of the above

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

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

7. At a quiet pond with crystal clear water, you decide to fish with a bow and arrow. You see a fish under the water. Where should you aim your arrow?

(A) Directly at the point where you see the fish.
(B) At a point closer to the surface than where you see the fish.
(C) At a point deeper in the water than where you see the fish.
(D) At a point that depends on the depth of the pond.

8. If a glass lens is submerged in water, what happens to the focal length of the lens? (The index of refraction of glass is larger than the index of refraction of water.)

(A) Its magnitude increases.
(B) It stays the same.
(C) Its magnitude decreases.
(D) It changes sign.
(E) Its magnitude increases or decreases depending on whether the lens is a converging lens or a diverging lens.

9. The index of refraction of diamond is 2.42. This means that light of a given colour has

(A) a speed in diamond that is 2.42 times faster than in a vacuum, and a wavelength in diamond that is 2.42 times longer than in a vacuum.
(B) a speed in diamond that is 2.42 times faster than in a vacuum, and a wavelength in a vacuum that is 2.42 times longer than in diamond.
(C) a speed in a vacuum that is 2.42 times faster than in diamond, and a wavelength in diamond that is 2.42 times longer than in a vacuum.
(D) a speed in a vacuum that is 2.42 times faster than in diamond, and a wavelength in a vacuum that is 2.42 times longer than in diamond.
(E) a speed in diamond that is the same as in a vacuum, and a wavelength in a vacuum that is 2.42 times longer than in diamond.

10. The critical angle for a beam of light passing from water into air is 48.8°. This means that light travelling in the water and striking the water-air interface at an angle of incidence less than 48.8°

(A) will all be reflected.
(B) will all be transmitted.
(C) will be partially transmitted and partially reflected.
(D) will be absorbed so that no light is transmitted or reflected.
(E) will change colour.

11. A thermally isolated system initially contains a hot piece of copper and a cold piece of aluminum. The copper and the aluminum are allowed to come into thermal contact with each other. 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 it takes for the system to come to thermal equilibrium?

(A) The aluminium.
(B) The copper.
(C) Neither, both experience the same size gain or loss of heat.
(D) The object whose initial temperature was furthest away from the final temperature of the system.
(E) The answer cannot be determined without knowing the masses of the objects.

12. A hole is drilled in a metal plate. When the plate is heated, what happens to the diameter of the hole?

(A) It increases.
(B) It decreases.
(C) It remains the same.
(D) It may increase or decrease depending on the relative sizes of the plate and the hole.
(E) It may increase or decrease depending on how fast the plate is heated.

13. The air in a room consists principally of nitrogen and oxygen. The molecular weight of nitrogen (N_2) is 28 g/mole and the molecular weight of oxygen (O_2) is 32 g/mole. The air is in thermal equilibrium. Which statement is true?

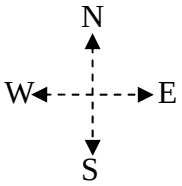
(A) The average speeds of the nitrogen and oxygen molecules are equal.
(B) The average kinetic energies of the nitrogen and oxygen molecules are equal.
(C) The oxygen molecules have average speeds that are greater than for the nitrogen molecules.
(D) The nitrogen molecules have average kinetic energies that are greater than for the oxygen molecules.
(E) None of the above statements are true.

14. Vectors $\vec{\mathbf{M}}$ and $\vec{\mathbf{N}}$ satisfy the equation $\vec{\mathbf{M}} + \vec{\mathbf{N}} = 0$. Which one of the following statements must be correct?

(A) Vectors $\vec{\mathbf{M}}$ and $\vec{\mathbf{N}}$ are at right angles to each other.
(B) Vectors $\vec{\mathbf{M}}$ and $\vec{\mathbf{N}}$ point in the same direction.
(C) Vector $\vec{\mathbf{M}} = 0$ and vector $\vec{\mathbf{N}} = 0$.
(D) Vectors $\vec{\mathbf{M}}$ and $\vec{\mathbf{N}}$ have the same magnitudes.
(E) The magnitude of $\vec{\mathbf{M}}$ is the negative of the magnitude of $\vec{\mathbf{N}}$.

15. A woman out for an afternoon stroll starts at the corner of Broadway Avenue and Main Street. On the first leg of her journey she walks 1 km due north. On the second leg of her journey she walks along several streets eventually ending up at a point that is 1 km due East of her starting point. The displacement vector for the second leg of her walk is best described as

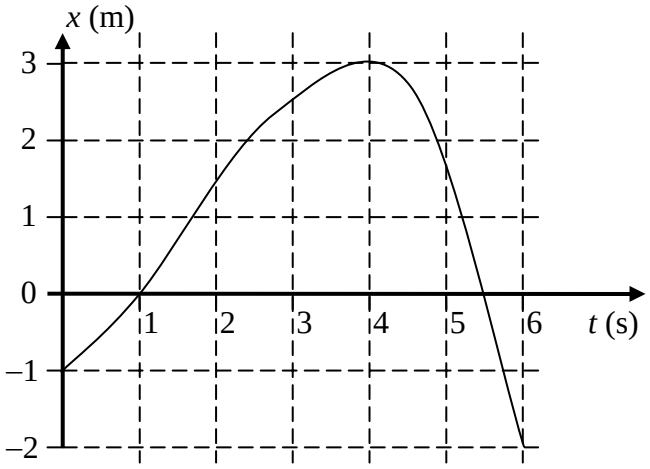
(A) $\sqrt{2}$ km, North of East.
(B) $\sqrt{2}$ km, North of West.
(C) $\sqrt{2}$ km, South of West.
(D) $\sqrt{2}$ km, South of East.
(E) 1 km, East



16. A train is initially moving forward along a straight track at a speed v_0. The brakes are applied and at a time t later the train is a distance d from where the brakes were applied and it is moving at a speed v_f. Assuming it is constant, the acceleration, a, of the train during this time interval t is

(A) $a = \dfrac{v_f - v_0}{d}$
(B) $a = \dfrac{v_f - v_0}{2t}$
(C) $a = \dfrac{v_f + v_0}{2t}$
(D) $a = \dfrac{v_f^2 - v_0^2}{2t}$
(E) $a = \dfrac{v_f^2 - v_0^2}{2d}$

17. This question and the following question refer to the graph at right which shows the displacement of a basketball player as a function of time as he runs up and down the court along a north-south line. ($x = 0$ is at the centre line and $+x$ is toward the north.)



What is the average velocity of the basketball player during the time interval from time $t = 1$ s to time $t = 6$ s?

(A) –3 m/s
(B) $-\frac{1}{6}$ m/s
(C) $+\frac{3}{5}$ m/s
(D) $+\frac{1}{2}$ m/s
(E) $-\frac{2}{5}$ m/s

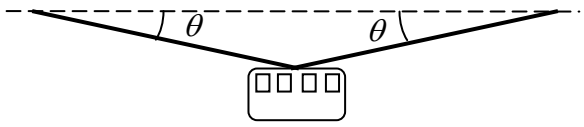
18. What is the approximate instantaneous velocity of the basketball player at time $t = 4$ s?

(A) zero.
(B) +3 m/s
(C) +1 m/s
(D) + ¾ m/s
(E) –2.5 m/s

19. A stone is thrown vertically upward on the surface of the Moon (no atmosphere). During the stone's flight, before it reaches its maximum height,

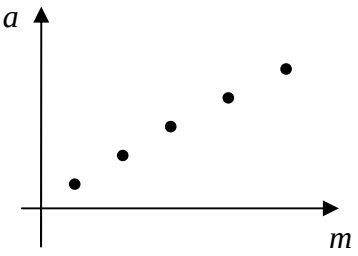
(A) its acceleration is upward.
(B) its acceleration is zero.
(C) the stone is in equilibrium.
(D) the net force on the stone is downward.
(E) the acceleration is decreasing and will become zero when the stone reaches its maximum height above the Moon's surface.

20. A gondola car, of mass m, is temporarily stationary and suspended at the halfway point between two supports. The cable sags at an angle θ below the horizontal as shown. Ignoring the mass of the cable, the tension in the cable is



(A) $\dfrac{mg}{\cos\theta}$
(B) $mg\cos\theta$
(C) $\dfrac{mg}{2\sin\theta}$
(D) $2mg\sin\theta$
(E) $\dfrac{mg\sin\theta}{2}$

21. The same net horizontal force is applied to several objects of different mass. Which one of the following graphs of the resulting acceleration plotted as a function of mass is the expected result of this experiment?

(A)


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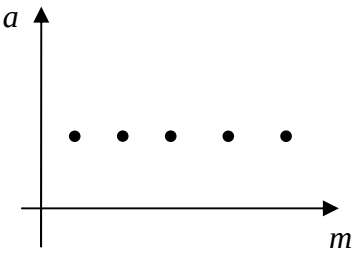

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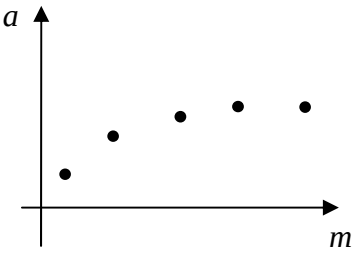

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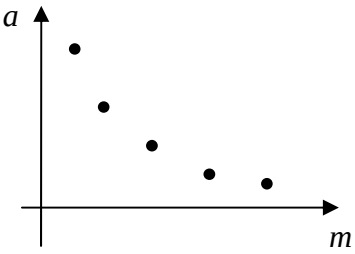
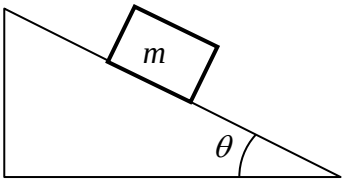


(E)


22. A block of mass m is <u>at rest</u> on an inclined plane that makes an angle θ with the horizontal. The magnitude of the force of static friction f_s between the block and the plane must be such that

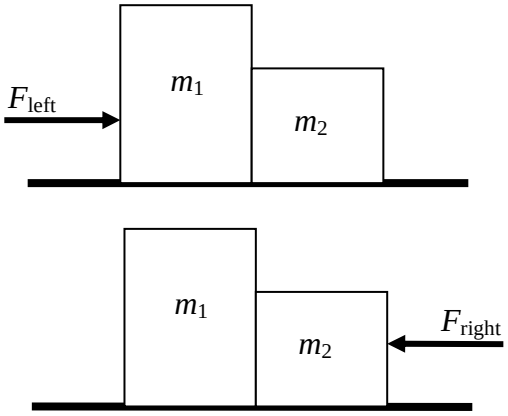


(A) $f_s > mg$
(B) $f_s > mg \cos\theta$
(C) $f_s = mg \cos\theta$
(D) $f_s = mg \sin\theta$
(E) None of the above: We need to know the coefficient of static friction between the block and the plane to give an answer.

23. An elevator, supported only by a steel cable, is descending at a constant speed. Ignoring air resistance, the tension in the cable is

(A) equal to the weight of the elevator and its occupants.
(B) greater than the weight of the elevator and its occupants.
(C) less than the weight of the elevator and its occupants.
(D) zero
(E) may be any of the above answers depending on the speed.

24. Two blocks with masses m_1 and m_2, with $m_1 > m_2$, are on a horizontal frictionless surface so that they are in contact with each other as shown. A horizontal force is applied from either the left or the right. The magnitudes of the forces are the same so that the result is a horizontal acceleration of the two blocks to the right or to the left. The magnitude of the contact force between the blocks m_1 and m_2 is



(A) larger when the force is from the right.
(B) larger when the force is from the left.
(C) the same in both cases.
(D) impossible to determine from the information given.

25. A truck has two times the mass of a car, however the car is moving with twice the speed of the truck. If K_t and K_c are the kinetic energies of the truck and the car respectively, it is correct to say that

(A) $K_t = K_c$.
(B) $K_t = 2K_c$.
(C) $2K_t = K_c$.
(D) $4K_t = K_c$.
(E) $K_t = 4K_c$.

26. Swimmers at a water park have a choice between two frictionless water slides (see figure). Although both slides drop over the same height h, slide 1 is straight while slide 2 is curved, dropping quickly at first and then levelling out. Assuming the swimmers start from rest at the top of the slides, how does the speed v_1 of a swimmer reaching the end of slide 1 compare to the speed v_2 of a swimmer reaching the end of slide 2?

(A) $v_1 = v_2$
(B) $v_1 > v_2$
(C) $v_1 < v_2$
(D) There is no simple relationship between v_1 and v_2.
(E) The answer depends on the relative masses of the swimmers.

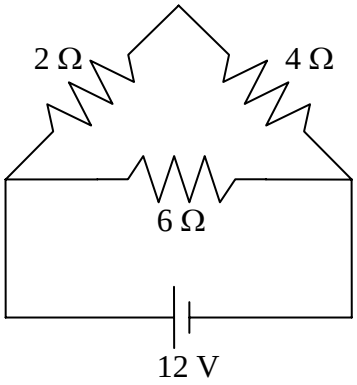
27. A book, of mass m, is lifted up from the floor a distance h, then transported horizontally a distance x, then lowered a distance d to finally be resting on a table top. The work done by the force of gravity on the book during this motion is

(A) $+mg(h + x + d)$
(B) $+mg(h - d)$
(C) $-mg\sqrt{(h-d)^2 + x^2}$
(D) $-mg(h + x + d)$
(E) $-mg(h - d)$

28. A length of copper wire has a resistance *R*. If the wire is replaced with another copper wire with twice the length and twice the radius, what is the resistance of the new copper wire?

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

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 passing through the 6 Ω resistor?
(A) 1 A
(B) 2 A
(C) 4 A
(D) 0.5 A
(E) 0.25 A

30. What is the power being supplied by the battery?

(A) 12 W
(B) 24 W
(C) 36 W
(D) 48 W
(E) 144 W

END OF EXAMINATION