UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

2024 Saskatchewan High School Physics Scholarship Competition

Friday May 9, 2024   Time allowed: 90 minutes

This competition is based on the Saskatchewan High School Physical Science 20 and Physics 30 curricula.

INSTRUCTIONS:

1.   You should have a test paper and an OMR (Optical Machine Readable) or Opscan computer scan sheet. The test paper consists of 10 pages, including this cover page. There are 30 questions. **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: _____

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_____

Postal Code: _____

Telephone: _____

Email address: _____

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

1. The width of a rectangular field is measured to be 27.0 m and its length is measured to be 135.2 m.
We calculate the area of the field by multiplying its width by its length and find that our calculator
display reads "3,650.40". The correct way to express the area to the appropriate number of significant
figures is

(A) 3650 m^2
(B) $3.650 \times 10^3 \text{ m}^2$
(C) 3650.4 m^2
(D) $3.65 \times 10^3 \text{ m}^2$
(E) $3.7 \times 10^3 \text{ m}^2$

2. The specific heat capacity of substance A is greater than that of substance B. Both A and B are at the
same initial temperature. Equal amounts of energy are added to each substance. Assuming that no
melting or vaporization occurs, which of the following can be concluded about the final temperature of
substance A, T_A, and the final temperature of substance B, T_B?

(A) $T_A > T_B$.
(B) $T_A = T_B$.
(C) $T_A < T_B$.
(D) We need more information to make a conclusion.

3. The length of an iron bar is measured when the bar is at a temperature of 20°C. If the temperature of
the bar is increased to 40°C we find that the length of the bar has increased by 0.024%. If the
temperature of the bar is increased to 50°C, what is the length of the bar now compared to when it was
20°C?

(A) It is 0.024% longer.
(B) It is 0.036% longer.
(C) It is 0.048% longer.
(D) It is 0.060% longer.
(E) It is 0.088% longer.

4. In the Compton effect, a photon of wavelength λ and frequency f collides with an electron that is
initially at rest. Which one of the following occurs as a result of the collision?

(A) The photon is absorbed completely.
(B) The photon gains energy, so the final photon has a frequency greater than f.
(C) The photon gains energy, so the final photon has a wavelength greater than λ.
(D) The photon loses energy, so the final photon has a frequency less than f.
(E) The photon loses energy, so the final photon has a wavelength less than λ.

5. A beam of red light (700 nm) strikes a metal surface and causes a stream of electrons to be emitted from the surface. What will happen if a beam of violet light (400 nm), with the same intensity as the red light, strikes the same surface?

(A) More electrons are emitted in a given time interval.
(B) It takes less time for the electrons to be emitted from the surface.
(C) No electrons are emitted.
(D) The electrons that are emitted are more energetic.
(E) The electrons that are emitted are less energetic.

6. By plucking and touching a guitar string in just the right way, a guitarist can make the string vibrate in its third harmonic. If the length of the string is L what must be the wavelength of the waves moving in the string when it is vibrating in the third harmonic?

(A) $\frac{3}{4}L$
(B) $\frac{1}{2}L$
(C) $\frac{1}{3}L$
(D) $\frac{2}{3}L$
(E) $\frac{3}{2}L$

7. Given that the strings of a guitar are the same length, is it possible for the strings to have the same tension but have different fundamental frequencies of vibration?

(A) Yes, and the lower the desired fundamental frequency, the smaller the required linear mass density of the string.
(B) Yes, and the lower the desired fundamental frequency, the larger the required linear mass density of the string.
(C) No, this is not possible because all strings at the same tension must have the same fundamental frequency.
(D) Yes, and the higher the desired fundamental frequency, the larger the required linear mass density of the string.
(E) No, this is not possible because all strings of the same length must have the same fundamental frequency.

8. A periodic wave passes by an observer who notices that the time between two consecutive wave crests is 2 seconds. Which one of the following statements about the wave is true?

(A) It has a wavelength of 2 metre.
(B) It has a period of ½ second.
(C) It has a frequency of ½ Hz.
(D) It has a speed of 2 m/s.
(E) It has an amplitude of 2 m.

9. As you travel down the highway in your car, an ambulance moves away from you at a high speed, sounding its siren at a frequency of 500 Hz. Which one of the following statements is **true**?

(A) You and the ambulance driver both hear a frequency greater than 500 Hz.
(B) You and the ambulance driver both hear a frequency less than 500 Hz.
(C) You and the ambulance driver both hear a frequency of 500 Hz.
(D) You hear a frequency greater than 500 Hz, whereas the ambulance driver hears a frequency of 500 Hz.
(E) You hear a frequency less than 500 Hz, whereas the ambulance driver hears a frequency of 500 Hz.

10. During the radioactive decay of an unstable nucleus in which a positron (β^+ particle) is emitted

(A) a neutron is transformed into a proton within the nucleus.
(B) a neutron is transformed into an electron within the nucleus.
(C) a proton is transformed into a neutron within the nucleus.
(D) a proton is also ejected from the nucleus.
(E) a neutron is also ejected from the nucleus.

11. A radioactive element has only 1/16 of its original activity after 60 days. The half-life of this element is,

(A) 6 days.
(B) 12 days
(C) 15 days
(D) 16 days
(E) 20 days

**12.** Which one of the following statements concerning electromagnetic (EM) waves is **<u>FALSE</u>**?

(A) The electric and magnetic fields in the EM waves are always perpendicular to each other.
(B) Higher frequency waves have more energy than lower frequency waves.
(C) EM waves move slower in high-index-of-refraction media.
(D) The index of refraction of a medium varies with the wavelength of the incident EM wave.
(E) The frequency of EM waves decreases in regions with higher index of refraction.

13. In a double-slit experiment, the light rays from the two slits that reach the second maximum on one side of the central maximum have traveled distances that differ by

(A) $(1/2)\lambda$ (B) λ (C) 2λ (D) 3λ (E) 4λ

14. The figure below shows light from material A with index of refraction n_A entering materials B and C with indices of refraction n_B and n_C. Rank the three indices of refraction from largest to smallest.

(A) $n_B > n_C > n_A$
(B) $n_C > n_A > n_B$
(C) $n_A > n_B > n_C$
(D) $n_C > n_B > n_A$
(E) $n_B > n_A > n_C$
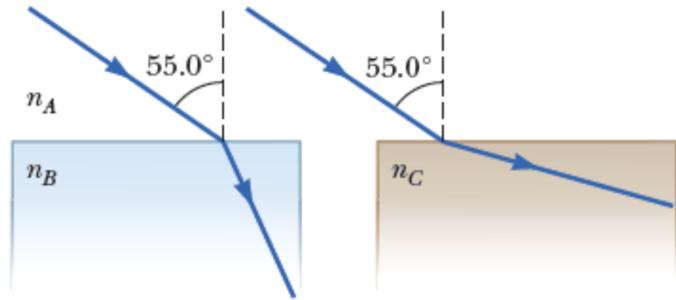
15. An object, represented by the arrow in the diagram, is placed half way between the focal point (labeled F) of a spherical concave mirror and the center of curvature (labeled C) of the mirror. The image of the arrow will be

(A) Virtual and upright.
(B) Virtual and upside down.
(C) Real and upright.
(D) Real and upside down.
(E) No image will be formed.
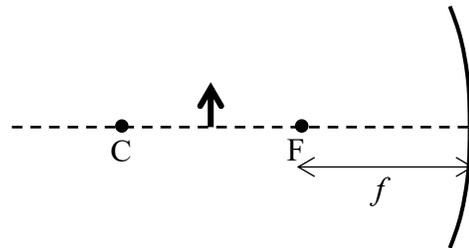
16. You have a choice of two converging lenses. Lens 1 has a focal length of 10.0 cm and Lens 2 has a focal length of 7.50 cm. Which one of the following scenarios will produce the **largest** possible focused image on the retina when one of the lenses is used as a simple magnifier? Suppose you have normal eye vision with a near point at 25 cm.

(A) Use Lens 1 and put the object at 25 cm from your eye.
(B) Use Lens 2 and put the object at 25 cm from your eye.
(C) Use Lens 1 and adjust the object position so that your eye is relaxed.
(D) Use Lens 2 and adjust the object position so that your eye is relaxed.
(E) Use Lens 2 and adjust the object position so that the image forms at 25 cm from your eye.

17. A motorist travels due north at 60 km/h for two hours. She then reverses her direction and travels due south at 120 km/h for 1 hour. What is the average speed of the motorist?

(A) 60 km/h
(B) 70 km/h
(C) 80 km/h
(D) 90 km/h
(E) 100 km/h

18. Two balls are released from rest from the top of a building. Ball 1 is released first, and ball 2 is released one second after. Which one of the following statements is **false** regarding the motion of balls 1 and 2? (Air resistance may be ignored.)

(A) The distance between each ball is always constant after they have been released.
(B) The acceleration of each ball is equal.
(C) The speed of ball 2 is always 9.80 m/s larger than the speed of ball 1.
(D) The time of flight for each ball will be equal.
(E) At a time of two seconds after ball 2 is released, the velocity and acceleration of each ball is in the same direction.

19. A juggler throws a bowling pin straight up in the air. After the pin leaves their hand and while it is in the air, which statement is true?

(A) The velocity of the pin is always in the same direction as its acceleration.
(B) The velocity of the pin is opposite its acceleration on the way up.
(C) The velocity of the pin is in the same direction as its acceleration on the way up.
(D) The acceleration of the pin is zero.
(E) The velocity of the pin is never in the same direction as its acceleration.

20. 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?
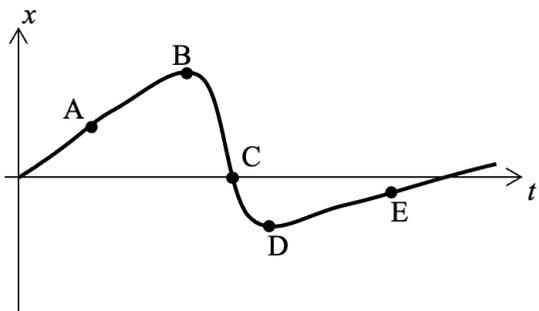

21. A block of mass M is held motionless on a frictionless inclined plane by means of a string attached to a vertical wall as shown in the drawing. What is the magnitude of the tension T in the string?

(A) zero
(B) Mg
(C) $Mg \cos \theta$
(D) $Mg \sin \theta$
(E) $Mg \tan \theta$
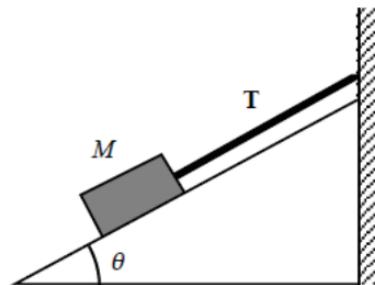
22. A store sign is held in place by two ropes: a horizontal rope that attaches to a wall and a rope at an angle of 45° that is attached to the roof. The tension in the horizontal rope is T. What is the weight of the sign?
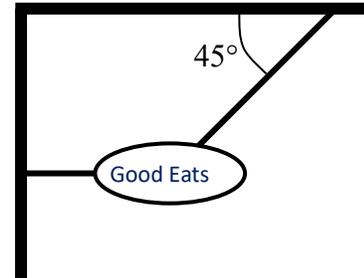
(A) T

(B) $\sqrt{2}\,T$

(C) $T/\sqrt{2}$

(D) $2T$

(E) $T/2$

23. A spring-loaded gun is aimed horizontally and is used to launch balls after the spring is loaded (the spring is compressed). The gun is at a fixed position above the floor. How does the horizontal range of the projectile change if the spring compression is doubled?

(A) The range stays the same.

(B) The range will be 1.4 times larger.

(C) The range will be two times larger.

(D) The range will be four times larger.

(E) The answer depends on the spring constant of the gun.

24. A 5-kg object is moving to the right at 4 m/s and collides with a 4-kg object moving to the left at 5 m/s. The objects collide and stick together. Which one of the following statements is correct regarding the combined system after the collision? You may assume that no external forces act during the collision.

(A) The combined object has the same kinetic energy as the system had before the collision.

(B) The combined object has more kinetic energy than the system had before the collision.

(C) The combined object has no kinetic energy.

(D) The combined object has less momentum than the system had before the collision.

(E) The combined object has more momentum than the system had before the collision.

25. A pendulum bob, of mass m, is suspended from a string of length L. The bob is pulled to one side so that it is a height $L/4$ above its freely hanging level, as shown. If the bob is now released from rest, the speed of the bob when it is at its lowest point is given by
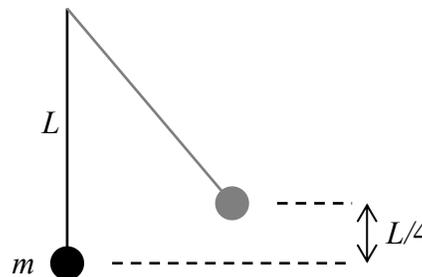
(A) $v = \dfrac{mgL}{8}$.

(B) $v = \sqrt{\dfrac{gL}{8}}$.

(C) $v = \sqrt{\dfrac{gL}{2}}$.

(D) $v = \sqrt{\dfrac{mgL}{2}}$.

(E) $v = \dfrac{gL}{2}$.

26. A car of mass m drives into an underpass at a constant speed v. The rounded bottom of the underpass has a radius of curvature of R in the vertical plane. What is the magnitude of the normal force acting on the car when the car reaches the bottom of the underpass?
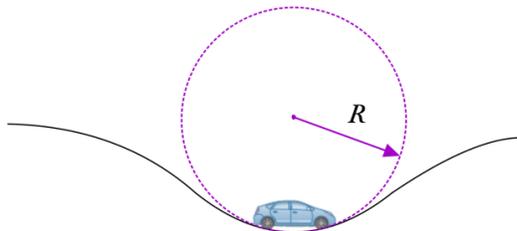
(A) $mg + \dfrac{mv^2}{R}$ (B) $mg - \dfrac{mv^2}{R}$ (C) mg (D) $\dfrac{mv^2}{R}$ (E) 0

27. A car enters a round-about and travels in a circle with constant speed. Which one of the following statements is **true**?

(A) The car is moving at constant speed and has no acceleration.
(B) The car experiences a force outward from the circle.
(C) There are no forces acting on the car.
(D) The car has acceleration directed toward the centre of the round-about.
(E) Work is done on the car by the force of gravity.

28. A conducting sphere is initially uncharged. A negative charge is brought near to the sphere but does not touch it. While the negative charge is near the sphere, a wire connected to ground is momentarily touched to the sphere on the side that is furthest from the charge. The negative charge is then removed. What will be the final state of the sphere?
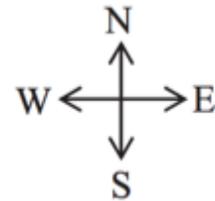
(A) It will have a positive charge on the side that was near the negative charge brought near it, and a negative charge on the other side.
(B) It will have a negative charge on the side that was near the negative charge brought near it, and a positive charge on the other side.
(C) It will be uncharged.
(D) It will have a net negative charge.
(E) It will have a net positive charge.

29. Two positive point charges Q and $2Q$ are separated by a distance R. If the charge $2Q$ experiences a force of magnitude F when the separation is R, what is the magnitude of the force on the charge Q when the separation is increased to $2R$?

(A) $F/4$
(B) $F/2$
(C) F
(D) $2F$
(E) $4F$

30. During a lightning strike, negative charges move vertically from a cloud to the ground. In what direction is the lightning strike deflected by the Earth's magnetic field? Assume that the Earth's magnetic field is directed toward the North.

(A) North
(B) East
(C) South
(D) West
(E) The lightning strike is not deflected.

END OF EXAMINATION