UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

2012 Saskatchewan High School Physics Scholarship Competition

May 9, 2012 Time: 90 minutes

This competition is based on the Saskatchewan High School Physics Curriculum for Physics 20 and Physics 30 including a few questions from the optional units.

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: _____

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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.

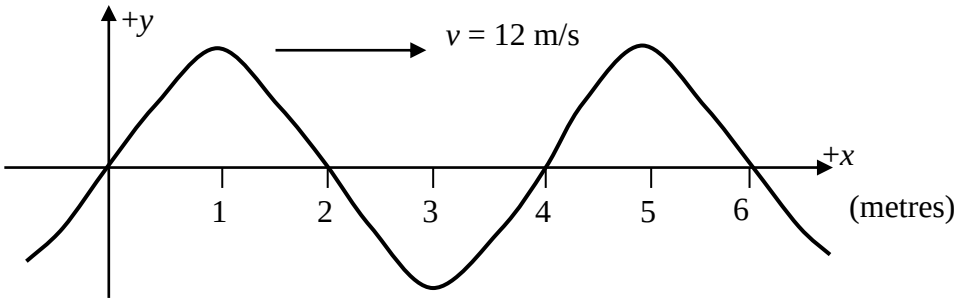
1. On a long straight country road, the distance from my front gate to my neighbor's front gate is 1.24 km. Continuing along the road, the distance from my neighbor's front gate to the next front gate, where my friend Fred lives, is 0.532 km. What is the distance from my front gate to Fred's front gate, to the correct number of significant figures?

(A) 1.7 km.
(B) 1.8 km.
(C) 1.77 km.
(D) 1.772 km.
(E) 1.7720 km.

2. A quantity used in nuclear and particle physics, called the "cross section", is measured in a unit called the barn. This unit is defined so that 1 barn = 10^{-24} cm^2. A microbarn must be

(A) 10^{-18} cm^2
(B) 10^{-21} cm^2
(C) 10^{-27} cm^2
(D) 10^{-30} cm^2
(E) 10^{-33} cm^2

3. The diagram shows a snapshot of a wave travelling in the $+x$ direction. The wave moves at a speed of 12 m/s.

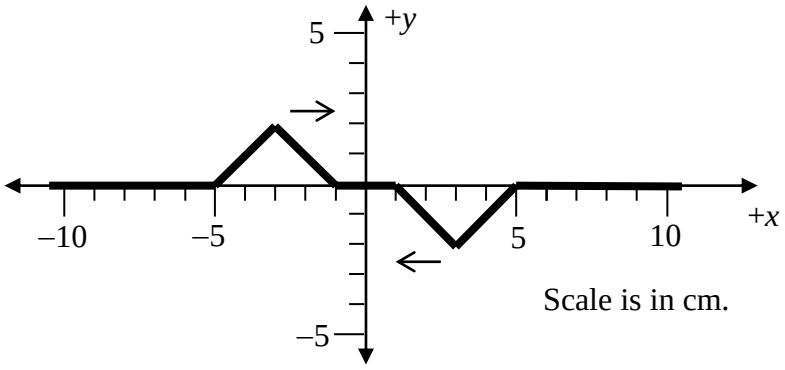


The frequency and wavelength of the wave are
(A) 3 Hz and 2 m.
(B) 12 Hz and 4 m.
(C) 6 Hz and 2 m.
(D) 3 Hz and 4 m.
(E) 2 Hz and 6 m.

4. A simple pendulum swings back and forth with a period *T* when the pendulum is located in a classroom on the surface of the Earth near sea level. The same pendulum is taken to the top of a high mountain where the acceleration due to gravity is about 10% less than it is at sea level. At the top of the mountain the period of the pendulum will be

(A) the same as *T*.
(B) a bit less than *T*.
(C) a bit more than *T*.
(D) about one tenth of *T*.
(E) about ten times *T*.

5. The diagram below shows two triangular wave pulses moving along a rope toward each other. Both pulses are moving at a speed of 2 cm/s. The diagram show the situation at time $t = 0$.



At time $t = 1$ s the displacement of the rope at $x = 0$ will be
(A) $y = 0$.
(B) $y = +1$ cm.
(C) $y = +2$ cm.
(D) $y = +4$ cm.
(E) $y = -2$ cm.

6. When one tunes a guitar by changing the tension in the guitar string, which properties of a standing wave in the guitar string are changed?

(A) The wave speed only.
(B) The frequency only.
(C) The wavelength only.
(D) The wave speed and the wavelength.
(E) The wave speed and the frequency.

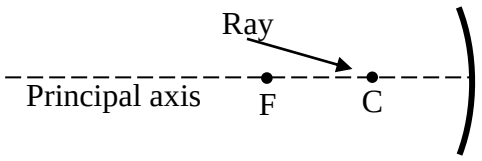
7. A guitar string is vibrating at a frequency *f* and the standing wave pattern has two nodes in the string (not including the nodes at the fixed ends of the string). What is the fundamental frequency for a standing wave in this string?

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

8. What happens when a beam of yellow light travelling in air passes into glass with a refractive index of 1.5?

(A) The frequency of the light increases by a factor of 1.5 and its wavelength remains the same.
(B) The frequency of the light decreases by a factor of $\frac{1}{1.5}$ and its wavelength remains the same.
(C) The wavelength of the light increases by a factor of 1.5 and its frequency remains the same.
(D) The wavelength of the light decreases by a factor of $\frac{1}{1.5}$ and its frequency remains the same.
(E) Both the wavelength and frequency remain the same because its colour remains the same.

9. A light ray travelling at an angle with respect to the principal axis of a concave mirror passes through the centre of curvature, C, of the mirror as shown in the diagram below. The focal point of the mirror is labelled F in the diagram.



The light ray after reflecting off the mirror will
(A) pass through the focal point.
(B) be parallel to the principal axis.
(C) will be reflected at an angle so that it never crosses the principal axis.
(D) will cross the principal axis at a point further from the mirror than F.
(E) will again pass through the centre of curvature.

10. A little mirror used by a dentist to see inside the mouth is a concave mirror with a focal length of 2.5 cm. Held 2.0 cm from a tooth, it provides a magnification of

(A) 0.5
(B) 2
(C) 4
(D) 5
(E) 10

11. A converging lens has a focal length *f*. Which one of the following types of images **cannot** be formed by this lens regardless of where the object is place?

(A) An image that is on the other side of the lens as the object, is upside down, and larger than the object.
(B) An image that is on the other side of the lens as the object, is upside down, and smaller than the object.
(C) An image that is on the same side of the lens as the object, and the distance between the lens and the image is less than *f*.
(D) An image that is on the same side of the lens as the object, is right side up, and larger than the object.
(E) An image that is on the same side of the lens as the object, is upside down, and smaller than the object.

12. The critical angle for a ray of light passing from water into air is 48.8°. This means that a ray of light which has an angle incidence that is

(A) less than 48.8° is totally reflected.
(B) less than 48.8° is partially transmitted and partially reflected.
(C) less than 48.8° is totally transmitted.
(D) greater than 48.8° is partially transmitted and partially reflected.
(E) greater than 48.8° is totally transmitted.

13. It is well known that aluminum has a smaller specific heat capacity than water. Consider two samples of aluminum and water that have the same mass. Both samples are initially at the same temperature. If the same amount of heat is added to each sample what will happen?

(A) Both samples will be at the same temperature that is higher than their initial temperature.
(B) The aluminum sample will be at a temperature lower than its initial temperature and the water sample will be at a temperature that is higher than its initial temperature.
(C) The aluminum sample will be at a temperature that is lower than the water sample temperature.
(D) The aluminum sample will be at a temperature that is higher than the water sample temperature.
(E) The aluminum sample will be at a temperature higher than its initial temperature and the water sample will be at a temperature that is lower than its initial temperature.

14. Consider two samples that have the same mass. Sample A is ice which is initially at 0° C. Sample B is water which is initially at 0° C. The specific heat capacity of ice is one half of the specific heat capacity of water. The two samples are heated until each sample has reached a temperature of 10° C. Which statement is correct?

(A) Sample A absorbed exactly half the heat as sample B.
(B) Sample A absorbed less heat than sample B.
(C) Sample A absorbed more heat than sample B.
(D) Sample A absorbed exactly twice the heat as sample B.
(E) Both samples absorbed the same amount of heat.

15. If you double your distance from a constant sound source that is radiating equally in all directions, what happens to the sound intensity level you hear?

(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 drops by 10 dB.

16. On the mythical planet Mongo the inhabitants use a length unit of a glong, which is the length of the leader's breathing tube. A Mongoian walks 3 glongs northeast from the methane fountain, then walks 4 glongs northwest. How far from the methane fountain is he now?

(A) 7 glongs
(B) 5 glongs
(C) 4 glongs
(D) 3 glongs
(E) 1 glong

17. Jason rides his bicycle along a straight road for one hour. He covers a distance of 6 km in the first 20 minutes and then he changes speed and covers 8 km in the next 40 minutes. What is his average speed for his trip?

(A) 10 km/h
(B) 14 km/h
(C) 15 km/h
(D) 20 km/h
(E) 30 km/h

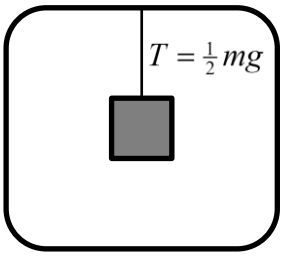
18. A ballast bag is dropped from a hot-air balloon when the balloon is at a height h above the ground. When the bag reaches the ground it is moving at speed v. Later, when the hot-air balloon is at a height h_2 above the ground another ballast bag is dropped. When this bag reaches the ground it is moving at speed $2v$. We may neglect the effect of friction with the air. How is height h_2 related to height h?

(A) $h_2 = 4h$
(B) $h_2 = 2h$
(C) $h_2 = \sqrt{2}h$
(D) $h_2 = 3h$
(E) There is not enough information given to determine an answer.

19. A garbage truck crashes head-on into a Smart car and the two come to rest in a cloud of flies. Which vehicle experiences the greater magnitude impact force during the collision?

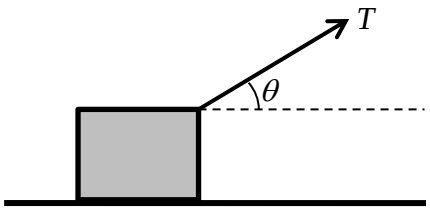
(A) The Smart car.
(B) The garbage truck.
(C) Neither, they both experience the same magnitude force.
(D) Neither, they both experience zero force.
(E) Not enough information is given to determine an answer.

20. A box of mass m is hanging from the roof of an elevator by a string. The tension in the string is $T = \frac{1}{2}mg$. The acceleration of the elevator is



(A) $\frac{1}{2}g$ downward.
(B) $\frac{1}{2}g$ upward.
(C) $\frac{3}{2}g$ downward.
(D) $\frac{3}{2}g$ upward.
(E) zero.

21. A box of mass *m* is pulled along a surface as shown in the diagram. The pulling force of magnitude *T* is at an angle θ to the horizontal. The coefficient of kinetic friction between the box and the surface is μ_k. The magnitude of the acceleration of the box is



(A) $a = \dfrac{T\cos\theta}{\mu_k m} g$

(B) $a = \dfrac{T\cos\theta}{m} - \mu_k g$

(C) $a = \dfrac{T(\cos\theta - \mu_k \sin\theta)}{m} - \mu_k g$

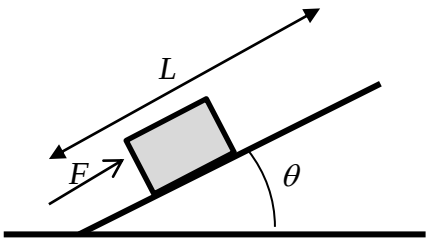
(D) $a = \dfrac{T(\cos\theta + \mu_k \sin\theta)}{m} - \mu_k g$

(E) $a = T\cos\theta - \mu_k mg$

22. Albert and Bruno move identical boxes equal distances in a horizontal direction. In each case the box is stationary before it is moved and again stationary after it has been moved. Albert slides his box along the surface, which is frictionless, while Bruno lifts his box, carries it the distance, and then sets it down. Compare the work that Albert and Bruno each do on their boxes.

(A) Albert and Bruno do the same amount of non-zero work.
(B) Albert and Bruno both do zero work.
(C) Albert does more work than Bruno.
(D) Albert does less work than Bruno.
(E) Since we are not told the relative times taken to move the boxes we cannot say anything about the work done.

23. A packing crate with mass *m* is pushed up a distance *L* on a plane inclined at an angle θ. The pushing force is parallel to the plane. The crate starts from rest at the bottom and at the top it is moving at speed *v*. There is negligible friction between the crate and the plane. The work done by the pushing force on the crate is



(A) $mgL\sin\theta$

(B) $mgL\cos\theta$

(C) $mgL\sin\theta + \frac{1}{2}mv^2$

(D) $mgL\cos\theta + \frac{1}{2}mv^2$

(E) $mgL\sin\theta - \frac{1}{2}mv^2$

24. A constant horizontal force F pushes on an object with mass m which is initially at rest on a horizontal frictionless surface. After being pushed for a time t the speed of the mass is v. The same force F pushes on a second object with mass $2m$, which is also initially at rest on the same frictionless surface. After being pushed for the same time t the speed of the second object is V. How is V related to v?

(A) $V = \frac{1}{2}v$
(B) $V = \frac{1}{\sqrt{2}}v$
(C) $V = 2v$
(D) $V = \sqrt{2}v$
(E) $V = v$

25. A bug is riding on the rim of a wheel of radius r. The wheel completes one rotation every T seconds. The angular speed of the bug (in radians/second) is

(A) $\frac{2\pi}{T}$
(B) $\frac{r}{T}$
(C) $\frac{2\pi\, r}{T}$
(D) $\frac{1}{T}$
(E) $\frac{T}{2\pi}$

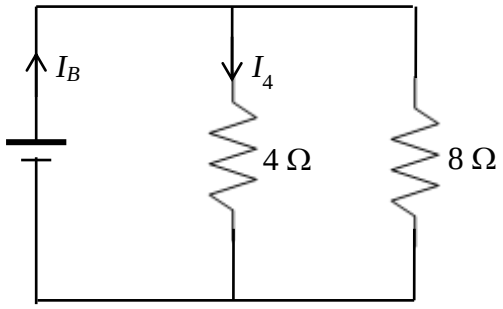
26. The starship Enterprise comes across a new planet. The planet has a moon that goes around the planet in a circular orbit. The moon completes one orbit in a time period T. Captain Picard puts the Enterprise in a circular orbit around the planet so that the radius of the Enterprise's orbit is one quarter of the radius of the moon's orbit about the planet. What is the time for the Enterprise to complete one orbit about the planet?

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

27. An object that weighs 100 N floats with three-quarters of its volume beneath the surface of the water. What buoyant force acts on the object?

(A) 25 N
(B) 50 N
(C) 75 N
(D) 100 N
(E) The answer cannot be determined without knowing the density of the object compared to the density of water.

28. In the circuit shown, the current flowing through the battery, I_B, is related to the current flowing through the 4 Ω resistor, I_4, by

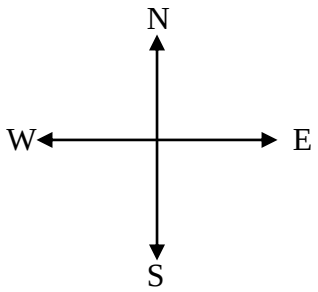


(A) $I_B = \frac{1}{2} I_4$
(B) $I_B = 2I_4$
(C) $I_B = 12I_4$
(D) $I_B = \frac{3}{2} I_4$
(E) $I_B = 3I_4$

29. In the Hydrogen atom there is an electric attraction force between the nucleus and the electron. If the distance between the electron and the nucleus was doubled, what would happen to the magnitude of the force between the nucleus and the electron?

(A) It would become essentially zero.
(B) It would double.
(C) It would be one-half of what it was before.
(D) It would be one-quarter of what it was before.
(E) It would not change.

30. In a region of space where there is a magnetic field that points vertically downward, toward the ground, an electron moves toward the East. What is the direction of the magnetic force on the electron?



(A) Up
(B) North
(C) South
(D) West
(E) Down

31. When the radioactive nucleus $^{215}_{83}\mathrm{Bi}$ decays, leaving behind the daughter nucleus $^{215}_{84}\mathrm{Po}$, what is released?

(A) A proton.
(B) A neutron.
(C) A positron and a neutrino.
(D) An electron and an anti-neutrino.
(E) An alpha particle.

END OF EXAMINATION