UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

High School Physics Scholarship Competition

May 5, 2004 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 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: _____

_____

_____

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.

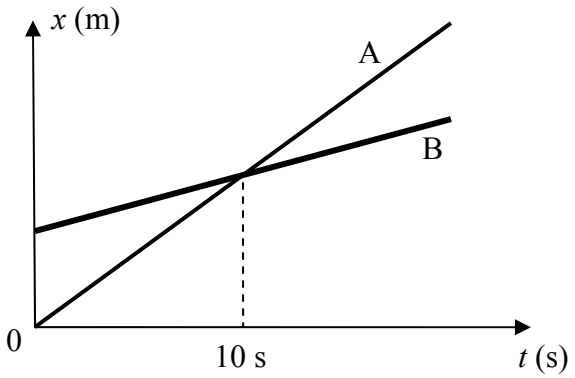
1. If we find that $v = A\lambda$, where v is a speed and λ is a length, what would be the SI units of A?

(A) s^{-1}
(B) m^2/s
(C) m/s^2
(D) s
(E) kg.m/s

2. The acceleration due to gravity on the surface of the Moon is one-sixth of what it is on the Earth's surface. An object is measured to have a mass of 6 kg on the Earth's surface. What will be its mass on the surface of the Moon?

(A) 1 kg
(B) 3 kg
(C) 6 kg
(D) 18 kg
(E) 36 kg

3. The positions of two bicycle riders, A and B, moving along a straight road in the $+x$ direction, are plotted on the following diagram.

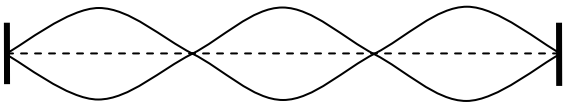


At the time $t = 10$ s
(A) the speed of rider B is greater than that of rider A.
(B) riders A and B have the same velocity.
(C) rider A is ahead of rider B.
(D) rider A is moving faster than rider B.
(E) rider B is slowing down.

4. Waves on a lake pass under a floating bird causing the bird to bob up and down with a period of 2 seconds. If the distance from wave trough to wave trough is 3 metres, the speed of the water wave is

(A) 6 m/s.
(B) 3 m/s.
(C) 2 m/s.
(D) 1.5 m/s.
(E) 1.0 m/s.

5. A violin string, which is fixed at both ends, vibrates with a frequency of 12 Hz with a standing wave pattern that looks like the pattern shown



What is the string's fundamental frequency?

(A) 4 Hz
(B) 8 Hz
(C) 16 Hz
(D) 24 Hz
(E) 36 Hz

6. Destructive interference occurs when two waves, with the same frequency and wavelength, overlap such that

(A) they have a phase difference of 90°.
(B) they have a phase difference of 180°.
(C) they have a phase difference of 360°.
(D) they have a phase difference of –90°.
(E) they are in phase.

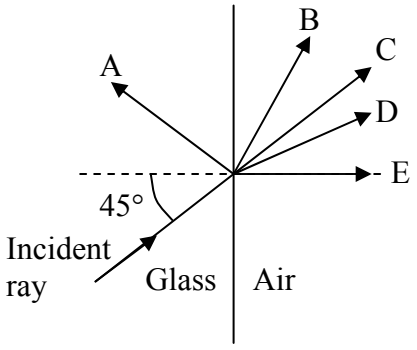
7. Which one of the following statements is a **FALSE** statement?

(A) Sound waves are longitudinal pressure waves.
(B) Light travels very much faster than sound.
(C) The transverse wave on a vibrating string is different from a sound wave.
(D) Sound waves can travel through a vacuum.
(E) "Pitch" in music is closely related to frequency of a sound wave.

8. As light passes from air into water (which has a higher refractive index)

(A) the speed increases and the frequency increases.
(B) the speed decreases and the wavelength increases.
(C) the speed decreases and the wavelength decreases.
(D) the speed decreases and the frequency decreases.
(E) the speed increases and the wavelength decreases.

9. The critical angle for total internal reflection at a glass-air interface is 42°. Which ray in the diagram below best shows the direction of a light ray (with an angle of incidence of 45°) after it encounters the glass-air interface?



10. A plane mirror forms an image that is

(A) Real and upright.
(B) Virtual and upright.
(C) Real and upside down.
(D) Virtual and upside down.
(E) Real and left-right inverted.

11. If you stand in front of a convex (diverging) mirror at a distance from the mirror equal to the magnitude of its focal length,

(A) you will not see an image because it is at infinity.
(B) you will see your image and you will appear larger.
(C) you will see your image and you will appear smaller.
(D) you will see your image and it will have the same height as you.
(E) you will not see an image because it is behind you.

12. A converging lens has a focal length f. An object is placed a distance of $3f$ from the lens. How far from the lens is the image?

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

13. A simple astronomical telescope is made from two converging lenses, an objective lens with focal length f_o, and an eyepiece with focal length f_e. When viewing the stars, with your eye relaxed (i.e. looking at an image at infinity) the distance between the two lenses that produces a well-focused image is

(A) $f_o + f_e$.
(B) f_o.
(C) $2(f_o + f_e)$.
(D) f_o/f_e.
(E) $f_o - f_e$.

14. A thermally isolated system contains a hot piece of aluminum and a cold piece of copper. The aluminum and the copper are in thermal contact. 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 them to reach thermal equilibrium?

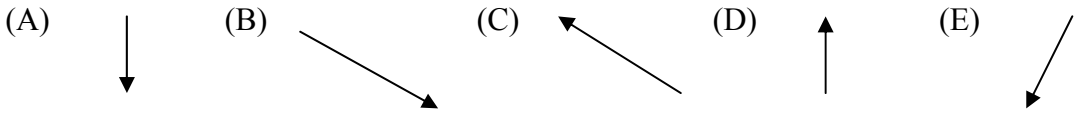
(A) The aluminum.
(B) The copper.
(C) Neither, they both experience the same size gain or loss of heat.
(D) It is impossible to tell without knowing the masses of the aluminum and copper.

15. When a vapour condenses into a liquid

(A) heat energy leaves the substance and its temperature increases.
(B) heat energy enters the substance and its temperature increases.
(C) heat energy leaves the substance and it temperature remains the same.
(D) heat energy enters the substance and it temperature remains the same.
(E) heat energy leaves the substance and its temperature decreases.

16. Consider the two displacement vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$,

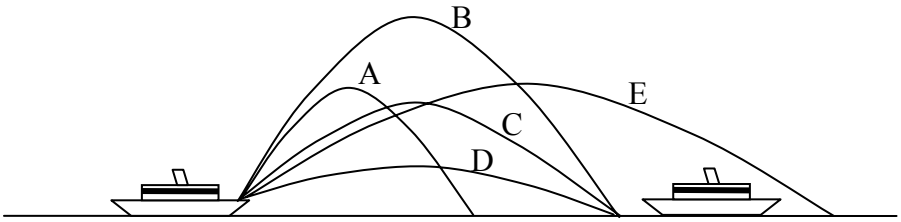
Which vector best represents the difference $\vec{\mathbf{B}} - \vec{\mathbf{A}}$?



17. On the Moon (where there is no air resistance) a bullet A is dropped, from rest, at the same time that another bullet B is fired horizontally from a rifle. Both bullets leave from the same height above the horizontal ground. Which one of the following statements is correct?

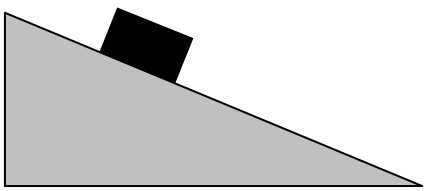
(A) Bullet A hits the ground before bullet B does.
(B) Both bullets hit the ground at the same time.
(C) Bullet B hits the ground before bullet A does.
(D) We need to know the masses of the bullets to decide which hits the ground first.
(E) Either bullet may hit the ground first; it depends on the value of the initial speed of bullet B.

18. Suppose that several projectiles are fired from a ship in an attempt to hit another ship. The projectiles have different initial speeds and different initial angles above the horizontal. All of them miss! The path of each projectile is shown in the figure. Ignoring air resistance, which projectile was in the air for the longest time?

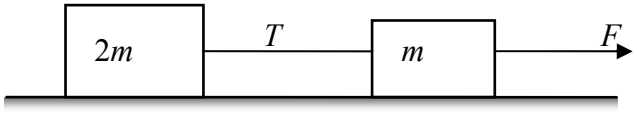


19. A box is sliding down the inclined plane shown at a <u>constant</u> speed. Which one of the following statements is correct?

(A) There are no forces acting on the box.
(B) There are no frictional forces acting on the box.
(C) The net force on the box is zero.
(D) Gravity is the only force acting on the box.
(E) The net force acting on the box is non-zero and constant.



20. Two blocks, tied together with a string, are being pulled along a frictionless surface with a constant horizontal force of magnitude F as shown. The first block has mass m and the second has mass $2m$. The acceleration of the blocks is a. What is the tension T in the string connecting the two blocks?



(A) $T = F$ (B) $T = ma$ (C) $T = 2ma$ (D) $T = F - 2ma$ (E) $T = 3ma$.

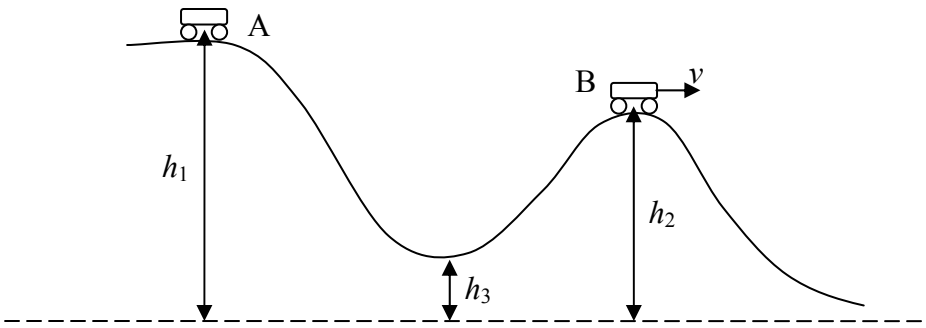
21. The kinetic energy of an object of mass m moving with speed v is K. A second object with a mass $2m$ is moving with a speed of $\frac{v}{2}$. The kinetic energy of the second object is

(A) $\frac{K}{4}$ (B) $\frac{K}{2}$ (C) K (D) $2K$ (E) $4K$

22. You and your friend want to go to the top of the Eiffel Tower. Your friend takes the elevator straight up. You decide to walk up the spiral stairway, taking longer to do so. You and your friend both weigh the same. Compare the change in gravitational potential energy experienced by you and your friend after you have both reached the top.

(A) It is impossible to compare them since the times taken and distances moved by you and your friend are not given.
(B) You friend's change in gravitational potential energy is greater than yours since she got to the top faster.
(C) Both of you have the same change in gravitational potential energy.
(D) Your change in gravitational potential energy is greater than your friend's since you travelled a greater distance getting to the top.

23. Consider the frictionless roller coaster in the picture. The car, of mass m, starts from rest at the top of the first hill at point A. What will be the speed of the car when it reaches the top of the second hill at point B?



(A) $v = \sqrt{mgh_2}$
(B) $v = \sqrt{2gh_1}$
(C) $v = \sqrt{mg(h_1 - h_2)}$
(D) $v = \sqrt{2g(h_1 + h_2 - h_3)}$
(E) $v = \sqrt{2g(h_1 - h_2)}$

24. A car of mass m is travelling with speed v when it strikes a parked station wagon, whose mass is $2m$. The bumpers lock together during this head-on collision so that just after the collision the two cars are moving together. Ignoring frictional effects, what is the speed of the two cars just after the collision?

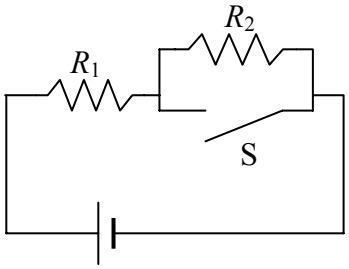
(A) There is not enough information given to answer the question.

(B) v (C) $\frac{v}{2}$ (D) $\frac{v}{3}$ (E) $\frac{v}{3m}$

25. Two charged objects attract each other with a certain force. If the charge on one of the objects is doubled while the charge on the other remains the same and the distance between the objects remains the same, the force between the objects

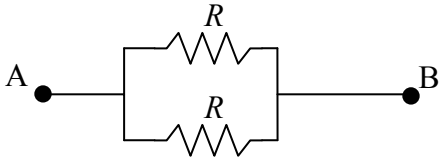
(A) is now zero.
(B) is now a repulsive force.
(C) is double what it was before.
(D) is four times what is was before.
(E) is one half what it was before.

26. Current is flowing through the resistors R_1 and R_2 in the circuit when the switch S is open as shown in the diagram. What happens when the switch S is closed?



(A) The current passing through the resistor R_1 increases.
(B) The current passing through the resistor R_2 increases.
(C) The current passing through the resistor R_1 decreases.
(D) The current passing through the resistor R_2 remains the same.
(E) The current passing through the resistor R_1 remains the same.

27. Consider the resistors connected as shown. Each resistor has resistance R.



The equivalent resistance between the terminals A and B is

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

28. In a neutral atom the number of protons in the nucleus is Z and the number of neutrons in the nucleus is N. The number of electrons in orbit about the nucleus is

(A) N
(B) Z
(C) $N + Z$
(D) $N - Z$
(E) $2Z$

END OF EXAMINATION