UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Saskatchewan High School Physics Scholarship Competition

May 4, 2005 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: _____

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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.

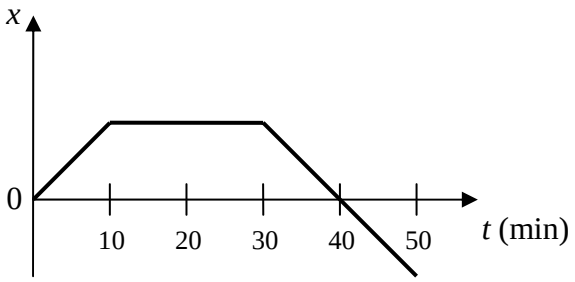
1. A quantity *k* is related to the quantities *v* (measured in units of m/s), *a* (measured in units of m/s^2) and the angle θ (measured in ° (degrees)) by the equation $k = \dfrac{2v\sin\theta}{a}$. What are the units of *k*?

(A) s
(B) m
(C) m/s
(D) s^{-1}
(E) None of the above.

2. A loonie is thrown up from the top of the Broadway Bridge. It rises to a maximum height before falling to hit the water below. If we ignore the effects of air resistance the acceleration of the loonie during its flight

(A) has maximum magnitude at its highest point.
(B) points upwards on the way up and downward on the way down.
(C) is zero at its highest point.
(D) has minimum magnitude at its highest point and increases to maximum magnitude just before it hits the water.
(E) is constant throughout the flight.

3. The position *x* of a jogger running along a straight road is shown in the graph. The jogger starts at position *x* = 0 at time *t* = 0.



Which one of the following statements is correct?
(A) The jogger is standing still at time *t* = 40 min.
(B) The jogger is standing still at time *t* = 20 min.
(C) The jogger is moving fastest at time *t* = 20 min.
(D) The jogger is back where he started from at time *t* = 50 min.
(E) The jogger is furthest from his starting point at time *t* = 40 min.

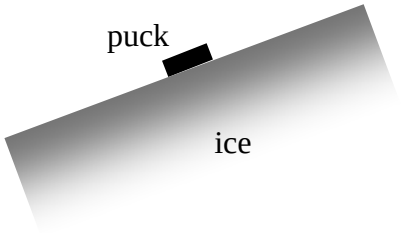
4. A box slides in a straight line across the floor. It starts out with a speed of 10 m/s and 2 seconds later it has slowed to a speed of 4 m/s while still moving in the same direction. Assume that it is sliding in the +*x* direction. What is its average acceleration during this 2 second time interval?

(A) +6 m/s^2
(B) –3 m/s^2
(C) –7 m/s^2
(D) –6 m/s^2
(E) +7 m/s^2

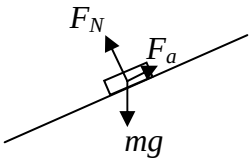
5. When the rocket engines of a starship are suddenly turned off while traveling in empty space, far from the gravitational effects of any star or planet, the starship will

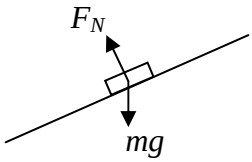
(A) stop immediately.
(B) slow down and then stop.
(C) start moving in the opposite direction.
(D) move with constant velocity.
(E) continue moving with constant acceleration.

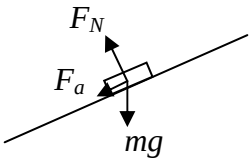
6. A hockey puck, of mass *m*, is sliding down an icy slope as shown. There is no friction between the puck and the ice.

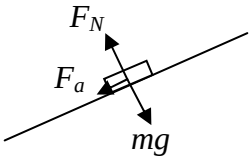


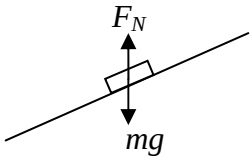
Which one of the following diagrams best represents the "Free Body Diagram" of all the forces on the puck as it slides?

(A) 

(B) 

(C) 

(D) 

(E) 

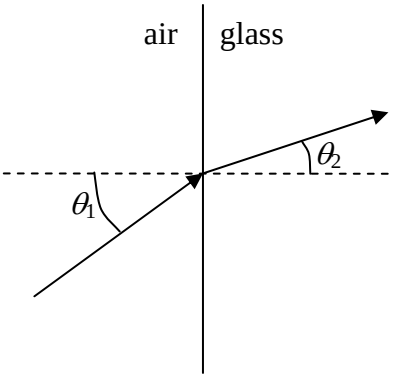
7. When travelling in a vacuum, the speed of all electromagnetic waves, which includes visible light,

(A) depends on the frequency of the light.
(B) is zero.
(C) is the same (approximately 3.00×10^8 m/s).
(D) depends on the wavelength of the light.
(E) depends on the energy of the light photons.

8. A concave (converging) mirror has a focal length *f*. An object, of height *h*, is placed a distance 2*f* from the mirror. The image formed by the mirror

(A) has height *h* and is upside down.
(B) has height 2*h* and is upside down.
(C) has height *h* and is right side up.
(D) has height ½*h* and is right side up.
(E) has height 2*h* and is right side up.

9. White light, travelling in air, strikes the surface of a glass block at an angle of incidence θ_1 as shown. The angle of refraction is θ_2. It is known that, in glass, blue light has a slightly higher index of refraction than red light. As a consequence,



(A) the angle of refraction, θ_2 is greater for blue light than for red light.
(B) the angle of refraction, θ_2 is greater for red light than for blue light.
(C) the angle of refraction, θ_2 is the same for both colours of light.
(D) the blue light is refracted while the red light is reflected.
(E) the red light is refracted while the blue light is reflected.

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 greater 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. Two objects, with different sizes, masses and temperature are placed in contact with each other. Heat energy travels

(A) from the larger object to the smaller object.
(B) from the more massive object to the less massive object.
(C) from the higher temperature object to the lower temperature object.
(D) from the higher density object to the lower density object.
(E) in a direction that cannot be determined without more information.

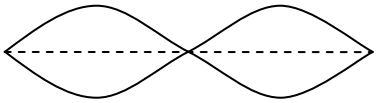
12. A chunk of ice at a temperature of –20°C is dropped into a thermally insulated container of cold water at 0°C. What happens in the container?

(A) The ice melts until thermal equilibrium is established.
(B) The water cools down until thermal equilibrium is established.
(C) Some of the water freezes and so the chunk of ice gets bigger. The ice is eventually at 0°C when thermal equilibrium is established.
(D) Some of the water freezes and so the chunk of ice gets bigger. The ice is eventually at –20°C when thermal equilibrium is established.
(E) There is not enough information given to say what will happen.

13. What is the speed of propagation of a wave which has a frequency of 12 Hz and a wavelength of 3 m?

(A) 12 m/s
(B) 3 m/s
(C) 0.25 m/s
(D) 4 m/s
(E) 36 m/s

14. A guitar string, fixed at both ends, has a fundamental frequency of 440 Hz. After plucking the string it is possible, by lightly touching the string in the centre, to make the string vibrate in the mode illustrated, with a node in the centre. What is the frequency of the note produced when the string is vibrating in this mode?

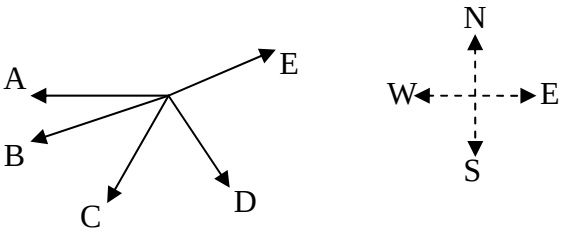


(A) 220 Hz
(B) 440 Hz
(C) 660 Hz
(D) 880 Hz
(E) 1760 Hz

15. Which one of the following is a vector quantity?

(A) Mass
(B) Temperature
(C) Acceleration
(D) Work
(E) Energy

16. A woman starts from Saskatoon and flies in her light plane, on the first leg of her journey, a distance of 100 km due North, she then flies, on the second leg of her journey, in a direction so that she ends up at a place that is 200 km due West of Saskatoon. Which vector best represents the direction of her displacement on the second leg of her journey?



17. An unknown horizontal force F acts on a stack of books resting on a frictionless horizontal table and the stack of books accelerates at 3 m/s^2 as a result. An additional mass of 1 kg is added to the stack of books. The same force F applied to the books plus the 1 kg, results in an acceleration of 2 m/s^2. What is the mass of the original stack of books?

(A) 1 kg
(B) 2 kg
(C) 3 kg
(D) 4 kg
(E) 5 kg

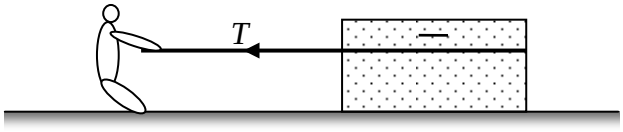
18. The mass of the Sun is approximately 10^6 times the mass of the Earth. If the magnitude of the gravitational force that the Sun exerts on the Earth is F, the magnitude of the gravitational force that the Earth exerts on the Sun is

(A) approximately 10^6F.
(B) approximately $10^{-6}F$.
(C) approximately $10^{-12}F$.
(D) equal to F.
(E) zero.

19. Planet Mongo has a mass that is twice the mass of Earth and it also has a radius that is twice that of Earth. If the acceleration due to gravity on the Earth's surface is g, the magnitude of the acceleration due to gravity on the surface of Mongo is

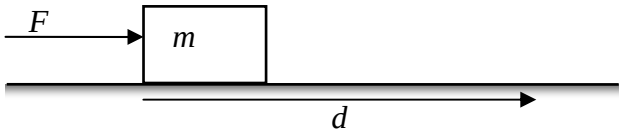
(A) $\frac{1}{4}g$
(B) $\frac{1}{2}g$
(C) g
(D) $2g$
(E) $4g$

20. A man is trying to move a heavy freezer (which does not have wheels on the bottom) across his basement floor. He ties a rope to it and pulls horizontally as hard as he can but the freezer still does not move. The coefficient of static friction between the freezer and the floor is μ_s, and the mass of the freezer is m. When he pulls such that the tension in the rope has magnitude T the magnitude of the friction force of the floor on the freezer is



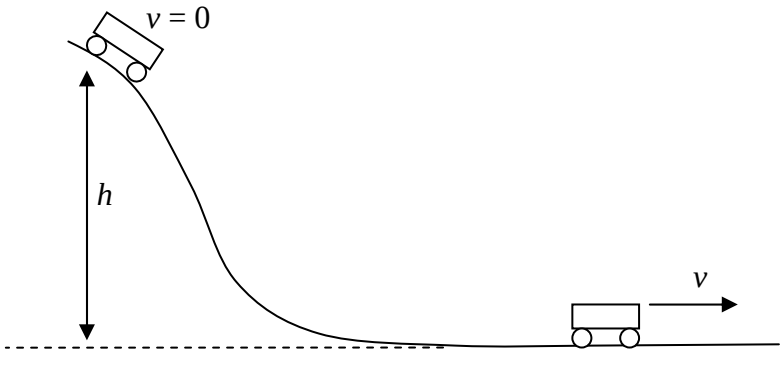
(A) T
(B) $T - \mu_s mg$
(C) $\mu_s mg$
(D) mg
(E) $T - mg$

21. A box of mass m is pushed along a horizontal table by a horizontal force of magnitude F. During the push the box moves a horizontal distance d in a time t. The work done on the box by the force is



(A) mgd
(B) Ft
(C) $\frac{1}{2}Fd^2$
(D) Fd
(E) $F\dfrac{d}{t}$

22. A roller coaster, of mass m, starts from rest at a height h above a horizontal part of the track. If friction is negligible, its speed, v, when it reaches the horizontal part of the track is



(A) $v = \sqrt{2mgh}$
(B) $v = mgh$
(C) $v = \sqrt{gh}$
(D) $v = 2gh$
(E) $v = \sqrt{2gh}$

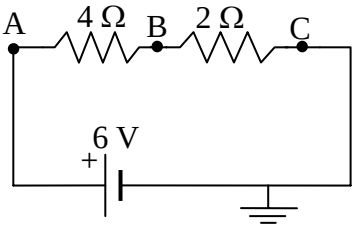
23. Compared to yesterday, today you did 3 times the work in one-third of the time. To do so your power output must have been

(A) the same as yesterday's power output.
(B) one-nineth yesterday's power output.
(C) one-third yesterday's power output.
(D) 3 times yesterday's power output.
(E) 9 times yesterday's power output.

24. A DC current of 10 amperes circulates in a circuit. How much charge passes a certain point in the circuit in 2 seconds?

(A) 5 Coulombs.
(B) 10 Coulombs.
(C) 20 Coulombs.
(D) 100 Coulombs.
(E) 200 Coulombs.

The following two questions refer to the circuit at right. The 6 V battery is an ideal battery with no internal resistance. You may assume that the ground is at a potential of 0 V.



25. What is the current passing through the 2 Ω resistor?

(A) $\frac{1}{3}$ A
(B) $\frac{1}{2}$ A
(C) 1 A
(D) 2 A
(E) 6 A

26. What is the potential at the point B in the circuit?

(A) +1 V
(B) +2 V
(C) +3 V
(D) +4 V
(E) +6 V

27. The number of protons in a nucleus is *Z*, the number of neutrons in a nucleus is *N*, and the atomic mass number is *A*. Which one of the following is correct?

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

END OF EXAMINATION