UNIVERSITY OF SASKATCHEWAN

Department of Physics and Engineering Physics

2019 Saskatchewan High School Physics Scholarship Competition

Thursday May 2, 2019 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 9 pages, including this cover page. There are 32 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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(Reverse side of cover page.)

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

1. Tripling the frequency of the radiation from a monochromatic source will change the energy content of the individually radiated photons by what factor?

(A) 0.33
(B) 1.0
(C) 1.33
(D) 1.73
(E) 3.0

2. If the absolute temperature of a radiating blackbody is tripled, then the peak wavelength emitted will change by what factor?

(A) 1/3
(B) 1
(C) 3
(D) 9
(E) 27

3. Blue light will not eject electrons from a certain metal; however, which one of the following types of light may possibly eject electrons from that metal?

(A) Microwave
(B) Infrared
(C) Ultraviolet
(D) Red light
(E) Green light

4. What will be the result if Young's double slit interference experiment is performed with the entire apparatus (source, slits, screen) immersed in water?

(A) There will be fewer interference fringes.
(B) The fringes will be further apart.
(C) The fringes will be closer together.
(D) There will be no interference fringes.
(E) The fringe pattern will be no different than if the experiment is done in air.

5. A slide containing two slits is illuminated with light from a source that emits only two spectral lines – a violet line of 400 nm wavelength and a red line of 600 nm wavelength. The resulting interference pattern is observed on a screen. Is it possible for there to be locations on the screen that are illuminated by both colours at the same time?

(A) No, this is not possible.
(B) Yes, but only if the two lights are coherent.
(C) Yes, but only if the two wavelengths are of exactly the same intensity.
(D) Yes, but only at locations where the order of the red fringe, m_{red}, is 2/3 m_{violet}.
(E) Yes, but only at locations where the order of the red fringe m_{red}, is 1.5 m_{violet}.

6. Let N_P and Z_P be the neutron number and atomic number of a parent nucleus that undergoes alpha decay, becoming a daughter nucleus. Let N_D and Z_D be the neutron number and atomic number of the daughter nucleus. Which one of the following statements is correct?

(A) $N_D = N_P + 2$
(B) $N_D = N_P$
(C) $N_D + Z_D = N_P + Z_P$
(D) $N_D = N_P - 2$
(E) $N_D = N_P - 4$

7. 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.

8. A cheetah can run at approximately 100 km/hour and a gazelle at 80.0 km/hour. If both animals are running at full speed, with the gazelle 70.0 m ahead, how long before the cheetah catches its prey?

(A) 12.6 s
(B) 25.2 s
(C) 6.30 s
(D) 10.7 s
(E) 9.80 s

9. Two objects of masses 10 kg and 20 kg are released simultaneously from the top of a 20-m tower and fall to the ground. If air resistance is negligible, which statement best describes this event?

(A) The 10-kg object hits the ground first.
(B) The 20-kg object hits the ground first.
(C) The terminal speed of the 20-kg object when it hits the ground is twice of that of the 10-kg object.
(D) The terminal speed of the 20-kg object when it hits the ground is half of that of the 10-kg object.
(E) Both objects hit the ground at the same time.

10. Starting from rest, a car accelerates down a straight road with constant acceleration a_1 for a time t_1, then the acceleration is changed to a different constant value a_2 for an additional time t_2. The total elapsed time is $t_1 + t_2$. Can the equations of kinematics be used to find the total distance traveled?

(A) No, because this is not a case of constant acceleration.
(B) No, because this is not a case of constant velocity.
(C) Yes, use $(a_1 + a_2)/2$ as the average acceleration and the total time in the calculation.
(D) Yes, use $a_1 + a_2$ as the acceleration and the average time $(t_1 + t_2)/2$ in the calculation.
(E) Yes, break the problem up into 2 problems, one with the conditions for the first time interval and the other with the conditions for the second time interval, noting that for the second time interval the initial velocity is that from the end of the first time interval. When done, add the distances from each of the time intervals.

11. A student adds two vectors with magnitudes of 200 and 40. Which one of the following is the only possible choice for the magnitude of the resultant?

(A) 40
(B) 100
(C) 200
(D) 260
(E) 280

12. A baseball is thrown by the center fielder (from shoulder level) to home plate where it is caught (on the fly at an equal shoulder level) by the catcher. At what point is the ball's speed at a minimum? Ignore air resistance.

(A) When it just left the center fielder's hand.
(B) When it just arrived at the catcher's mitt.
(C) When it is at the top of the trajectory.
(D) Speed is constant during entire trajectory.
(E) It is impossible to tell.

13. What condition must apply to a system's state of motion for it to be regarded as an inertial frame of reference?

(A) When it has decreasing velocity.
(B) When it has increasing velocity.
(C) When it has constant velocity.
(D) When it has constant acceleration.
(E) When it has decreasing acceleration.

14. The acceleration due to gravity on the Moon's surface is one-sixth that on Earth. An astronaut's life support backpack weighs 300 lb on Earth. What does it weigh on the Moon?

(A) 25 lb
(B) 50 lb
(C) 135 lb
(D) 300 lb
(E) 1800 lb

15. Two blocks, joined by a string, have masses of 6.0 and 9.0 kg. They rest on a frictionless horizontal surface. A second string, attached only to the 9-kg block, has horizontal force = 30 N applied to it. Both blocks accelerate. What is the tension in the string between the blocks?

(A) 12 N
(B) 15 N
(C) 18 N
(D) 20 N
(E) 28 N

16. Doug hits a hockey puck, giving it an initial velocity of 6.0 m/s. If the coefficient of kinetic friction between ice and puck is 0.050, how far will the puck slide before stopping?

(A)19 m (B) 25 m (C) 37 m (D) 45 m (E) 57 m

17. As a car moves forward on a level road at constant velocity, the net force acting on the tires is,

(A) greater than the normal force times the coefficient of static friction.
(B) equal to the normal force times the coefficient of static friction.
(C) equal to the normal force times the coefficient of kinetic friction.
(D) zero.
(E) It is impossible to tell.

18. A block is launched up an incline plane. After going up the plane, it slides back down to its starting position. The coefficient of friction between the block and the plane is 0.3. Which of the following statements best describes the speed of the block when it reaches the starting position on the trip down?

(A) It is the same as the launching speed.
(B) It is lower than the launching speed.
(C) It is higher than the launching speed.
(D) It may be lower or higher than the launching speed depending on the angle of inclination.
(E) It may be lower or higher than the launching speed depending on the mass of the block.

19. For a point on a spinning disc in uniform circular motion, which of the following quantities is not constant at all time?

(A) Its kinetic energy
(B) Its angular speed
(C) Its tangential speed
(D) Its angular acceleration
(E) Its centripetal acceleration

20. The unit of work, joule, is dimensionally the same as:

(A) newton/second
(B) newton/kilogram
(C) newton·second
(D) newton·meter
(E) newton/meter

21. Which of the following is an example of a non-conservative force?

(A) Gravitational force
(B) Coulomb force
(C) Spring force
(D) Friction
(E) A force that depends only on the position of the object.

22. A golf ball hits a wall and bounces back at 3/4 the original speed. What part of the original kinetic energy of the ball did it lose in the collision?

(A) 1/4
(B) 3/8
(C) 5/8
(D) 7/16
(E) 9/16

23. A professional skier reaches a speed of 56 m/s on a 30° ski slope. Ignoring friction, what was the minimum distance along the slope the skier would have had to travel, starting from rest?

(A) 110 m
(B) 160 m
(C) 320 m
(D) 640 m
(E) 720 m

24. A billiard ball collides in an elastic head-on collision with a second stationary identical ball. After the collision which of the following conditions applies to the first ball?

(A) It maintains the same velocity as before.
(B) It has one half its initial velocity.
(C) It has one quarter its initial velocity.
(D) It comes to rest.
(E) It moves in the opposite direction.

25. Alex throws a 0.15-kg rubber ball down onto the floor. The ball's speed just before impact is 6.5 m/s, and that just after is 3.5 m/s. What is the change in the magnitude of the ball's momentum?

(A) 0.09 kg·m/s
(B) 1.5 kg·m/s
(C) 4.3 kg·m/s
(D) 126 kg·m/s
(E) 9.80 kg·m/s

26. A moderate force will break an egg. However, an egg dropped on the concrete usually breaks, while one dropped on the grass usually doesn't break. This is because for the egg dropped on the grass:

(A) the change in momentum is greater.
(B) the change in momentum is less.
(C) the time interval for stopping is greater.
(D) the time interval for stopping is less.
(E) the size is larger.

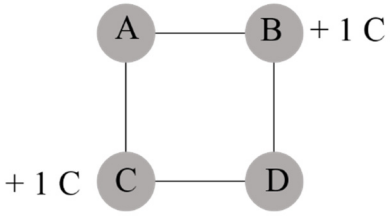
27. An Earth satellite is orbiting at a distance from the Earth's surface equal to one Earth radius (4000 miles). At this location, the magnitude of acceleration due to gravity (g) is what factor times the value of g on the Earth's surface?

(A) 4
(B) 2
(C) 1/2
(D) 1/4
(E) There is no acceleration since the satellite is in orbit.

28. Somewhere between the Earth and the Moon is a point where the gravitational attraction of the Earth is canceled by the gravitational pull of the Moon. The mass of the Moon is 1/81 that of the Earth. How far from the center of the Earth is this point?

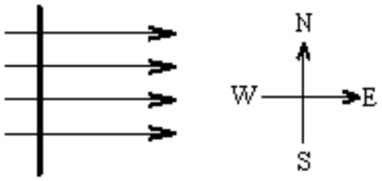
(A) 3/4 the way to the Moon
(B) 4/5 the way to the Moon
(C) 8/9 the way to the Moon
(D) 9/10 the way to the Moon
(E) 80/81 the way to the Moon

29. Four charges are at the corners of a square, with B and C on opposite corners. Charges A and D, on the other two corners, have equal charge, while both B and C have a charge of +1.0 C. What is the charge on A so that the force on B is zero?



(A) −1.0 C
(B) −0.50 C
(C) −0.35 C
(D) −0.71 C
(E) −2.0 C

30. A wire is lying horizontally in the north-south direction and the horizontal magnetic field is toward the east. Some positive charges in the wire move north and an equal number of negative charges move south. The direction of the force on the wire will be:



(A) East
(B) West
(C) Down, into the page
(D) Up, out of the page
(E) There is no magnetic force.

31. A beam of monochromatic light goes from material 1 with index of refraction n_1 into material 2 with index of refraction n_2. The frequency of light in material 1 is f_1 and in material 2 is f_2. What is the ratio of f_1/f_2?

(A) n_1/n_2
(B) n_2/n_1
(C) 1
(D) The ratio depends on the angle of incidence.
(E) The values of n_1 and n_2 must be known to find the answer.

32. For a standing wave in a guitar string, there must be at least:

(A) one node and one antinode.
(B) two nodes and one antinode.
(C) two antinodes and one node.
(D) two nodes and two antinodes.
(E) two antinodes and three nodes.

END OF EXAMINATION