

UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

2025 Saskatchewan High School Physics Scholarship Competition

Thursday May 8, 2025

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 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: _____

Postal Code: _____

Telephone: _____

Email address: _____

BLANK PAGE

(Reverse side of cover page.)

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

1. Which one of the following expressions gives the correct SI unit for power?

- (A) kg m s^{-2} (B) $\text{kg m}^2 \text{s}^{-2}$ (C) $\text{kg m}^2 \text{s}^{-1}$ (D) $\text{kg m}^3 \text{s}^{-2}$ (E) $\text{kg m}^2 \text{s}^{-3}$

2. A 100-g block of an unknown substance with a temperature of 70.0°C is placed in 200 g of water at 20.0°C . The system reaches an equilibrium temperature of 30.0°C . Assume no thermal energy is transferred to/from the environment. Which one of the following relations is correct regarding the specific heats of the block (c_{block}) and water (c_{water})?

- (A) $c_{\text{block}} = 4 c_{\text{water}}$
(B) $c_{\text{block}} = 2 c_{\text{water}}$
(C) $c_{\text{block}} = c_{\text{water}}$
(D) $c_{\text{block}} = 0.5 c_{\text{water}}$
(E) $c_{\text{block}} = 0.25 c_{\text{water}}$

3. In a Compton scattering experiment the incident (λ_0) and scattered (λ) photon wavelengths are measured for various photon scattering angles. How does the difference in wavelengths and difference in photon energies change between the incident and scattered photons as the photon scattering angle **increases**? Let $\Delta\lambda = \lambda - \lambda_0$ and $\Delta E = E - E_0$ respectively.

- (A) $\Delta\lambda$ increases and $|\Delta E|$ decreases.
(B) $\Delta\lambda$ increases and $|\Delta E|$ increases.
(C) $\Delta\lambda$ decreases and $|\Delta E|$ decreases.
(D) $\Delta\lambda$ decreases and $|\Delta E|$ increases.
(E) Nothing can be determined without knowing the incident photon wavelength and energy.

4. A hydrogen atom in the ground state absorbs a 12.75-eV photon. To which level is the electron promoted?

- (A) $n = 2$ (B) $n = 3$ (C) $n = 4$ (D) $n = 5$ (E) $n = 6$

5. Which one of the following will affect the maximum kinetic energy of electrons emitted in the photoelectric effect?

- (A) Increasing the intensity of the light.
(B) Changing the frequency of the light.
(C) Changing the angle at which the light strikes the metal.
(D) Immersing the experiment in water.
(E) All of the above will affect the electrons' kinetic energy.

6. 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 $\frac{1}{2}$ second.
- (C) It has a frequency of $\frac{1}{2}$ Hz.
- (D) It has a speed of 2 m/s.
- (E) It has an amplitude of 2 m.

7. A string (e.g. a guitar string) is stretched between two fixed points. When the string is made to vibrate, the lowest (fundamental) frequency of vibration is 100 Hz. When it is made to vibrate so that there are three nodes besides the fixed end points, the frequency of vibration is

- (A) 600 Hz (B) 400 Hz (C) 300 Hz (D) 50 Hz (E) 33 Hz

8. A sound wave is produced under water. The sound travels to the surface of the water and some of the sound is transmitted into the air. The speed of sound in water is 1450 m/s and the speed of sound in air is 330 m/s. As the sound passes from water into air, the effect on the frequency of the sound, f , and on the wavelength of the sound, λ , is

- (A) f and λ remain unchanged.
- (B) f remains unchanged, but λ decreases.
- (C) f remains unchanged, but λ increases.
- (D) f increases, but λ decreases.
- (E) f decreases, but λ increases.

9. A person hears maximum sound intensity while standing midway between two vehicles which are sounding horns of identical frequency. The sound waves travel outwards uniformly in all directions with wavelength λ . Which one of the following describes the correct distance the person must move towards one of the vehicles to be at a position of minimum sound intensity?

- (A) $\lambda/8$ (B) $\lambda/4$ (C) $\lambda/2$ (D) λ (E) 2λ

10. How does the composition of the daughter nucleus compare to that of the parent nucleus following an alpha decay?

- (A) The atomic number has decreased by 2 and the mass number has decreased by 2.
- (B) The atomic number has decreased by 4 and the mass number has decreased by 2.
- (C) The atomic number has decreased by 2 and the neutron number has decreased by 4.
- (D) The atomic number has decreased by 4 and the neutron number has decreased by 2.
- (E) The atomic number has decreased by 2 and the neutron number has decreased by 2.

11. The activity of a radioactive sample (with a single radioactive nuclide) decreases to one eighth its initial value in a time interval of 72 days. What is the half-life of the radioactive nuclide?

- (A) 8 days (B) 12 days (C) 16 days (D) 24 days (E) 32 days

12. Consider two slides. One has two slits, the other has five slits. Both slides have the same slit widths and slit spacings. Identical lasers are shone through the slides and the interference patterns are observed on a screen that is the same distance from each slide. Which one of the following statements concerning the interference patterns on the screen is correct?

- (A) The patterns are identical.
- (B) The bright fringes of the two-slit pattern are narrower and further apart than those of the five-slit pattern.
- (C) The bright fringes of the five-slit pattern are narrower and further apart than those of the two-slit pattern.
- (D) The bright fringes of the five-slit pattern are narrower and closer together than those of the two-slit pattern.
- (E) The bright fringes of the five-slit pattern are narrower but the same spacing as those of the two-slit pattern.

13. 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) $n_a > n_b > n_c$
- (B) $n_b > n_a > n_c$
- (C) $n_a > n_c > n_b$
- (D) $n_c > n_a > n_b$
- (E) $n_c > n_b > n_a$



14. An object is placed between a concave mirror's surface and its focal point. What characteristics does the image formed by the mirror have?

- (A) It is real and upright.
- (B) It is virtual and upright.
- (C) It is real and inverted.
- (D) It is virtual and inverted.
- (E) No image is formed.

15. The image of a tree 10 m high and 20 m away is 1.5 cm high when photographed. What is the focal length of the lens in the camera?

- (A) 10 mm
- (B) 1.5 cm
- (C) 2.6 cm
- (D) 3.0 cm
- (E) 1 m

16. Starting with an initial velocity, a vehicle which is confined to move along a straight line slows down at a rate of 4.0 m/s^2 . Which statement concerning the slope of the velocity versus time graph for this vehicle is correct?

- (A) The slope has a constant value of 4.0 m/s^2 .
- (B) The slope has a constant value of -4.0 m/s^2 .
- (C) The slope has a constant value of 4.0 m/s .
- (D) The slope is not constant and increases with increasing time.
- (E) The slope is not constant and decreases with increasing time.

17. Two students are on the top of a building. One of the students throws a heavy red ball horizontally from the top of the building with an initial velocity v_0 . While at the same time, the other student drops a lighter blue ball from rest straight down. Neglecting air resistance, which one of the following statements is true?

- (A) The blue ball reached the ground first.
- (B) The red ball reaches the ground first.
- (C) Both balls reach the ground at the same time and with the same final speed.
- (D) Both balls reach the ground at the same time but the blue ball has a greater final speed.
- (E) Both ball reach the ground at the same time but the red ball has a greater final speed.

18. A football is kicked at an angle of 30° above the horizontal ground. Which one of the following statements concerning the motion of the ball is correct just before the ball hits the ground? Ignore air resistance.

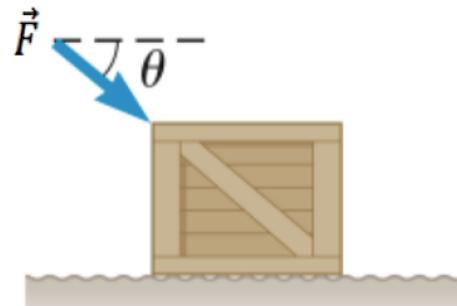
- (A) The velocity is directed opposite to the acceleration.
- (B) The velocity is directed parallel to the acceleration.
- (C) The velocity and acceleration make an angle of 60° .
- (D) The velocity and acceleration make an angle of 30° .
- (E) The velocity and acceleration are perpendicular to each other.

19. A projectile is launched at an angle of 60° above the horizontal. Ignoring air resistance, what fraction of its initial kinetic energy does the projectile have at the top of its trajectory?

- (A) 0 (B) $\frac{1}{4}$ (C) $\frac{1}{2}$ (D) $\frac{3}{4}$ (E) 1

20. A person pushes crate of weight w across a rough horizontal surface at a constant speed by applying a force F as shown in the figure. The force of kinetic friction between the crate and the floor is f_k , and F is directed at an angle θ below the horizontal. Which one of the following relations among the force magnitudes of w , f_k , F , and normal force n must be true?

- (A) $F=f_k$ and $n=w$
- (B) $F<f_k$ and $n>w$
- (C) $F<f_k$ and $n<w$
- (D) $F>f_k$ and $n>w$
- (E) $F>f_k$ and $n<w$

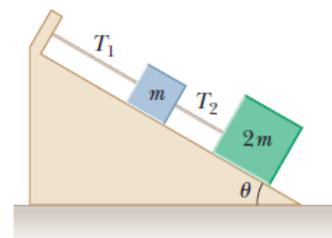


21. A brick of mass M slides down a ramp that has length L , coefficient of kinetic friction of μ_k and is inclined at an angle θ to the horizontal. If the brick slides down the entire ramp with a constant speed, what is the work done by friction?

- (A) 0
- (B) $-MgL \cos^2 \theta$
- (C) $-MgL \cos \theta$
- (D) $-MgL \sin \theta$
- (E) $-MgL \sin \theta \cos \theta$

22. Two blocks of masses m and $2m$ are held in equilibrium on a frictionless incline as in the figure. What is the tension T_1 in the upper cord?

- (A) $3mg \sin \theta$
- (B) $2mg \sin \theta$
- (C) $mg \sin \theta$
- (D) $3mg$
- (E) $2mg$



23. Novak Djokovic receives a shot with the tennis ball ($m = 60.0$ g) travelling horizontally at 35.0 m/s and returns it in the opposite direction with a speed of 55.0 m/s. What is the magnitude of the impulse delivered to the ball by the racket?

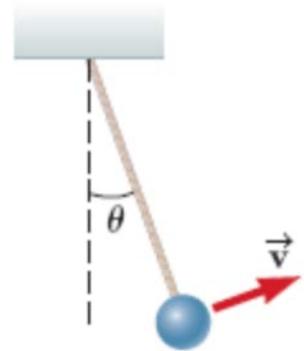
- (A) 1.20 kg m/s
- (B) 2.40 kg m/s
- (C) 3.00 kg m/s
- (D) 5.40 kg m/s
- (E) 10.8 kg m/s

24. An object of mass $2m$ moving with speed v in the $+x$ direction strikes an object of mass m which had been at rest. Following the collision, the object of mass m moves with speed v in the $+x$ direction. The velocity of the object of mass $2m$ after the collision is

- (A) zero.
- (B) $\frac{1}{2} v$ in the $+x$ direction.
- (C) $\frac{1}{2} v$ in the $-x$ direction.
- (D) v in the $+x$ direction.
- (E) v in the $-x$ direction.

25. One end of a cord is fixed and a small object with a mass m is attached to the other end, where it swings in a section of a vertical circle of radius r , as shown in the figure. At this instant, what is the tension in the string?

- (A) $mg + \frac{mv^2}{r}$
- (B) $mg \cos \theta + \frac{mv^2}{r}$
- (C) $mg \cos \theta - \frac{mv^2}{r}$
- (D) $mg \sin \theta + \frac{mv^2}{r}$
- (E) $mg \sin \theta - \frac{mv^2}{r}$

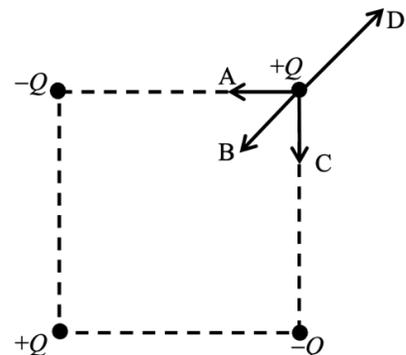


26. The work required to accelerate an object on a horizontal frictionless surface from a speed v to a speed $2v$ is

- (A) twice the work required to accelerate the object from $v = 0$ to v .
- (B) three times the work required to accelerate the object from $v = 0$ to v .
- (C) four times the work required to accelerate the object from $2v$ to $3v$.
- (D) not known without knowledge of the acceleration.
- (E) equal to the work required to accelerate the object from $v = 0$ to v .

27. Four charges of equal magnitude are placed at the four corners of a square. Two of the charges are positive and two of the charges are negative as shown. Which arrow best shows the direction of the net force on the positive charge in the corner?

- (A) A
- (B) B
- (C) C
- (D) D
- (E) The net force is zero



28. Suppose you have two spools of copper wire. The wire on one spool is thicker than the other (i.e. it has a larger diameter). You cut a short length of wire and a long length of wire from each spool. Which piece of wire will have the largest resistance between its ends?

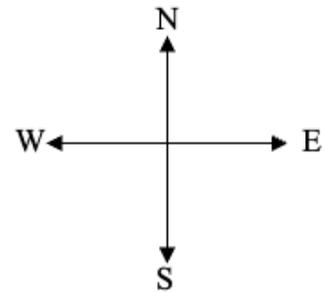
- (A) The short, thick wire.
- (B) The short, thin wire.
- (C) The long, thick wire.
- (D) The long, thin wire.
- (E) They would all have the same resistance since they are all made of the same material.

29. Which one of the following statements is correct? The $\text{kW}\cdot\text{h}$ is a unit of

- (A) power. (B) voltage. (C) charge. (D) energy. (E) current.

30. In a region of space, there is a magnetic field that points toward the North. An electron feels a magnetic force directed toward the East when it enters this region. In what direction the electron is moving?

- (A) Out of the page
- (B) Into the page
- (C) West
- (D) South
- (E) East



END OF EXAMINATION