



Mathematical Grammar School
a school with the High National Distinction status

The Mathematical Grammar School Cup

Physics Competition

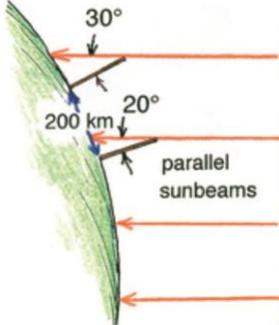
24.06.2020.

Instructions:

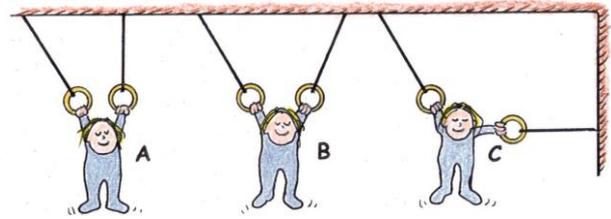
1. Duration of the competition is 3h. Maximum number of points is 80.
 2. Use the answer sheet only to give answers to all the questions.
 3. Use of calculators is allowed. If needed assume the gravitational acceleration to be 10 m/s^2 .
 4. It is not allowed to write on anything other than the answer sheet, notebook and the paper with questions.
 5. When finished, turn in the answer sheet and the notebook.
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Good luck! ☺

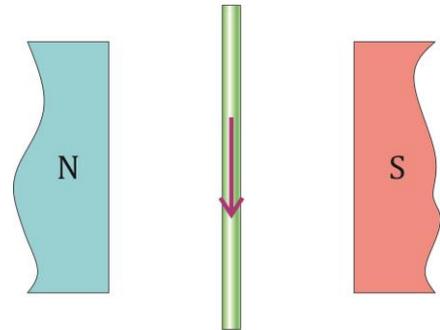
Circle the correct answer

- (1 point) After which scientist was the SI unit for voltage named:
 (A) Isaac Newton (B) James Watt (C) Andr -Marie Amp re (D) Alessandro Volta
 (E) George Ohm
- (1 point) How can the unit for voltage be expressed in terms of other SI units?
 (A) $J \cdot C$ (B) $\frac{C \cdot \Omega}{s}$ (C) A (D) $\frac{\Omega}{s}$ (E) $\frac{W}{C}$
- (1 point) Which one of the famous scientists won a Nobel prize?
 (A) Marie Curie (B) Isaac Newton (C) Aristotle (D) Stephen Hawking
 (E) James Clerk Maxwell
- (1 point) First MG Cup competition in physics was held at 10 a.m. on the 26th of June 2013. Approximately, how many seconds has passed since then till this very moment you are reading this question?
 (A) $2,2 \cdot 10^8 s$ (B) $4,2 \cdot 10^8 s$ (C) $1,6 \cdot 10^8 s$ (D) $1,9 \cdot 10^8 s$
 (E) $4,7 \cdot 10^8 s$
- (1 point) Two tall sticks, 200 km apart, are stuck vertically onto a spherical surface of a moon. One stick makes a 20^o angle with incoming sunbeams and casts a shadow directly toward the other stick, which at the same time is at 30^o to parallel sunbeams. What is the moon's diameter equal to?
 (A) 763,9 km (B) 1145,9 km (C) 2291,8 km
 (D) 1527,9 km (E) 1909,9 km
 
- (1 point) Which one of the following laws explains why electrical appliances heat up when turned on?
 (A) Gauss's law (B) Ampere's law (C) Ohm's law (D) Joule-Lenz law (E) Volta's law
- (1 point) Which instrument measures air pressure?
 (A) hydrometer (B) hygrometer (C) lactometer (D) altimeter (E) barometer
- (1 point) An optical fiber is a flexible, transparent fiber made by drawing glass or plastic to a diameter slightly thicker than that of a human hair. Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in communications. Which phenomenon makes it possible for optical fibers to successfully transmit light?
 (A) radiation (B) total internal reflection (C) refraction (D) dispersion (E) scattering
- (1 point) Which of the following is not a vector quantity?
 (A) acceleration (B) torque (C) force (D) work (E) magnetic field strength
- (1 point) Which is the correct relationship for the speed (v) of the sound waves in air, water and aluminium (Al)?
 (A) $v_{air} < v_{Al} < v_{water}$ (B) $v_{water} < v_{air} < v_{Al}$
 (C) $v_{water} < v_{Al} < v_{air}$ (D) $v_{air} < v_{water} < v_{Al}$ (E) $v_{air} = v_{water} = v_{Al}$

17. (2 points) Which one of the depicted positions A, B and C cannot be an equilibrium position?
 (A) A (B) B (C) C
 (D) all can be (E) none can be

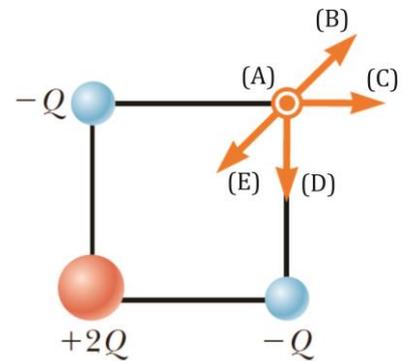


18. (2 points) What will be the direction of the force acting on a conductor, placed between the poles of a magnet, with the current flowing downward?
 (A) Left (B) right (C) out of the paper (toward us)
 (D) into the paper (away from us) (E) downward



19. (2 points) A dentist uses a spherical mirror to view the tooth of a patient. The required image is to be upright and five times the size of the tooth. Calculate the magnitude of the focal length of the mirror to be used if the tooth is to be viewed with the mirror 1 cm from the tooth.

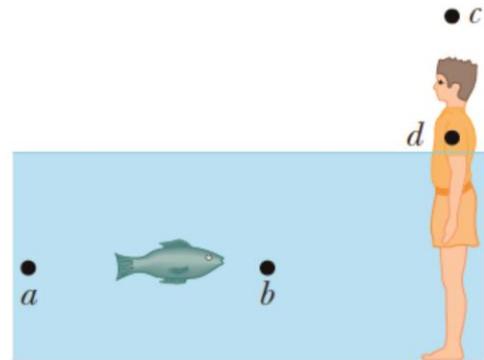
- (A) 2,5 cm (B) 1,66 cm (C) 0,83 cm
 (D) 0,5 cm (E) 1,25 cm



20. (2 points) Three charged particles are placed at the vertices of a square. What will be the direction of the electric field strength vector at the fourth vertex?

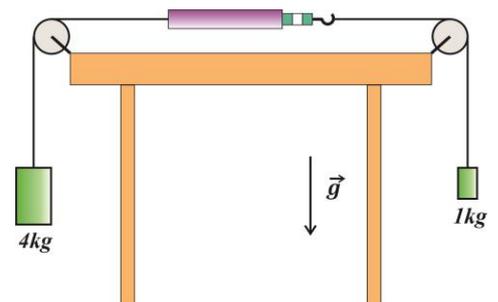
21. (2 points) Figure on the right shows a fish and a fish hunter in water.
 i. Does the hunter see the fish in the general region of point a or point b?
 ii. Does the fish see the eyes of the fish hunter in the general region of point c or point d?

	i.	ii.
(A)	a	c
(B)	b	c
(C)	a	d
(D)	b	d
(E)	none of the above	

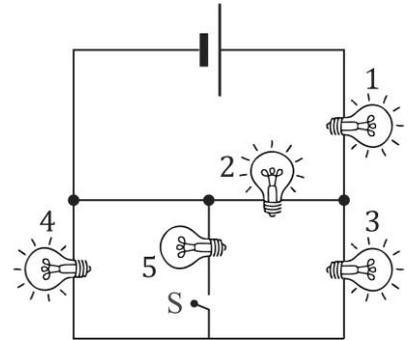


22. (3 points) The figure on the right shows two weights connected by light threads going over massless pulleys to a spring scale (newton meter) of negligible mass. When the system is released what will the spring scale show?

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



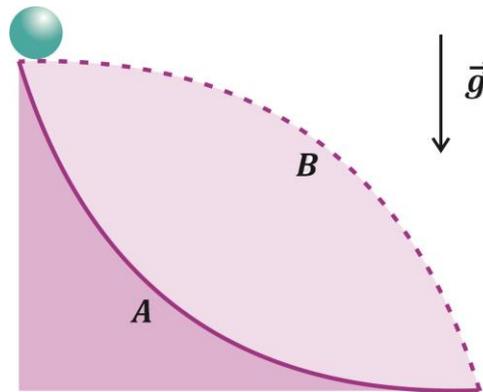
23. (3 points) Five identical light bulbs are connected into a circuit as shown. All wires are ideal with no resistance, and the ideal battery has emf \mathcal{E} . When the switch S in the circuit is closed, aside from bulb no. 5, which of the other bulbs brighten?



- (A) only bulb no. 4
- (B) only bulbs no. 1 and 3
- (C) only bulbs no. 3 and 4
- (D) only bulbs no. 2, 3 and 4
- (E) only bulbs no. 1, 3 and 4

24. (3 points) A small ball is released from the top of two different smooth curvilinear ramps A and B shown in the drawing. Which one of the following options correctly describes the relationship of the ball's speeds v_A and v_B at the bottom of the ramps as well as the times t_A and t_B it took the ball to reach the bottoms?

	speeds	times
(A)	$v_A = v_B$	$t_A > t_B$
(B)	$v_A > v_B$	$t_A < t_B$
(C)	$v_A = v_B$	$t_A = t_B$
(D)	$v_A < v_B$	$t_A > t_B$
(E)	$v_A = v_B$	$t_A < t_B$

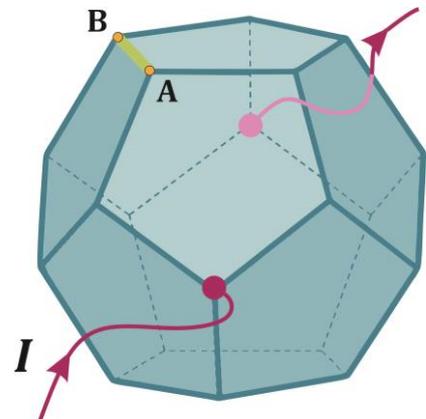


25. (3 points) A massive truck and an indestructible bumble bee travel toward each other with equal speeds v . After a perfectly elastic collision what will the speed of the bee be?



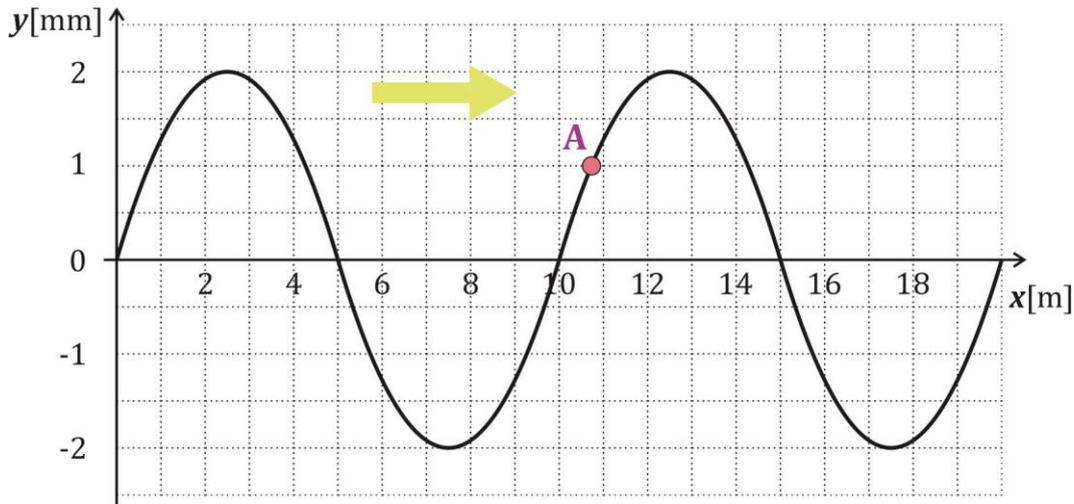
- (A) $0,5v$
- (B) v
- (C) $2v$
- (D) $3v$
- (E) $4v$

26. (4 points) Regular dodecahedron is a polyhedron which is composed of 12 regular pentagonal faces, three meeting at each vertex. It is one of the five Platonic solids among which are tetrahedron, cube and octahedron. It has 12 faces, 20 vertices and 30 edges. If we place 30 identical resistors along the edges of a dodecahedron and introduce a current I as is shown in the figure, what is the current that flows along the edge AB?



- (A) $I/2$
- (B) $I/3$
- (C) $I/6$
- (D) $I/8$
- (E) $I/12$

27. (2 points) Figure below shows a travelling wave on a tight wire propagating in the positive x -direction (to the right). What is the direction of velocity of the point A on the wire?



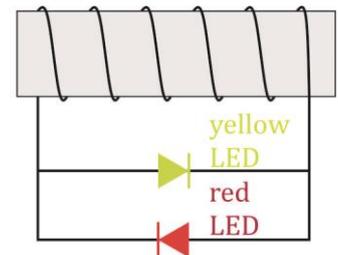
- (A) ↗ (B) ↙ (C) → (D) ↑ (E) ↓

28. (4 points) If the wave, mentioned in the previous question, propagates with a speed of 200 m/s what is the distance the point A covers in 1s?

- (A) 32 cm (B) 16 cm (C) 36 cm (D) 144 cm (E) 192 cm

29. (4 points) A strong magnet bar is held close to the opening of a solenoid as shown in the picture. Solenoid is connected to yellow and red LEDs (Light-emitting diodes). Symbol for LEDs in electric circuits is $\rightarrow|$ and they have the property of conducting electricity only in the direction the arrow points to which is when they turn on and emit light (this LED $\rightarrow|$ turns on when the current flows to the right). As the magnet moves away from the solenoid with constant velocity, which LED will turn on and what will be the direction of the force acting on the magnet due to induced electric current in the solenoid?

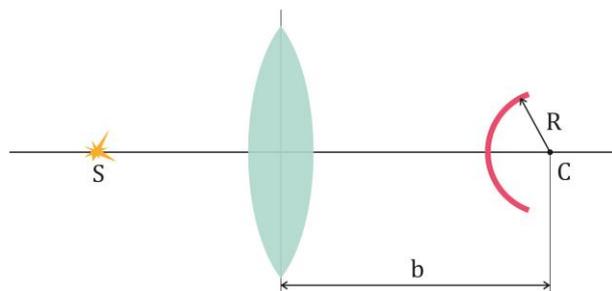
	LED that turns on	Force on the magnet
(A)	yellow	To the left
(B)	red	To the left
(C)	yellow	To the right
(D)	red	To the right
(E)	red	There is no force



30. (8 points) Two ants, Igor and Dushan, participate in a friendly chase. They draw a large circle of radius R on the floor. Igor starts out on the circle and Dushan at the center of the circle. They begin to run simultaneously. At all times, Igor runs along the circle at a speed v while Dushan runs directly toward Igor at a speed u ($u < v$). After a while, Dushan notices that the distance between them is no longer changing. What is that constant distance?

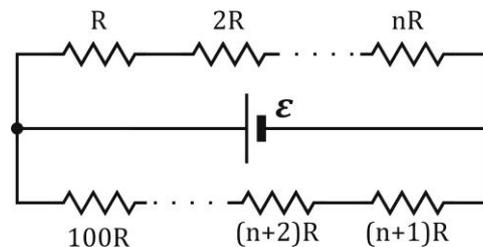
- (A) $R\sqrt{v^2 - u^2}/v$ (B) $R/2$ (C) $R/3$ (D) Ru/v (E) $Ru/\sqrt{v^2 + u^2}$

31. (8 points) Optical system shown in the figure consists of a thin converging lens, whose focal length is 10 cm , and a convex spherical mirror having a radius of $R = 5\text{ cm}$. Center of the mirror is located on the optical axis $b = 20\text{ cm}$ away from the lens. What is the sum of possible distances of a point-like light source from the lens such that its image forms at the exact location of the source?



- (A) 25 cm (B) 50 cm (C) 68 cm (D) 120 cm (E) 74 cm

32. (8 points) Resistors $R, 2R, \dots, 100R$ are connected in a single loop in the order of increasing resistance. One terminal of an ideal battery with emf ε is connected between resistors R and $100R$. Between which two resistors should the other terminal be connected so that the battery current is the smallest possible?



- (A) $40 \leq n \leq 50$ (B) $50 < n \leq 60$ (C) $60 < n \leq 70$
 (D) $70 < n \leq 80$ (E) $80 < n \leq 90$

The end!

