BAZINGA! PHYSICS

JOIN US!

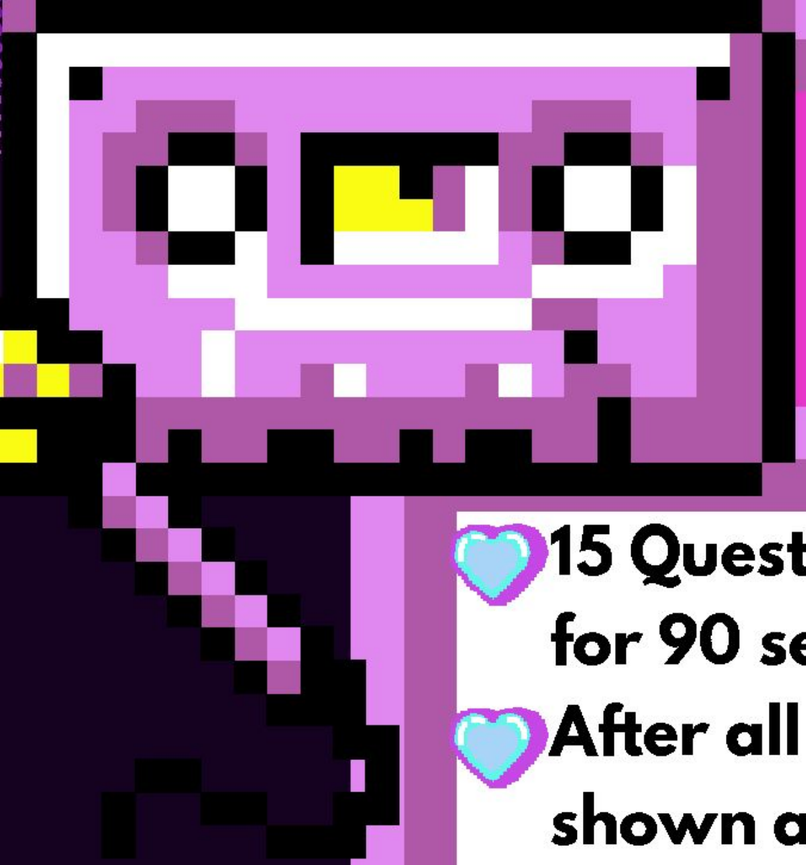
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BAZINGA! PHYSICS

PRELIMS

START NOW!



RULES

- 15 Questions, one by one, will be shown on the screen for 90 seconds each.
- After all Questions have been shown once, they will be shown again in the same order, for 30 seconds each.
- Write all answers neatly in the sheet provided (with your name and roll number on top).
- In the event of a tie, the person who solves more star-marked questions will qualify.



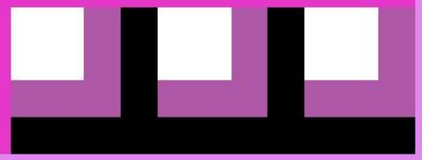
AND WE START

MAY THE FORCE BE WITH YOU

QUESTION 1 COMING UP



QUESTION 1



A cylindrical tank of height H and radius R is completely filled with water. Suppose we can drill a hole at any point on its curved surface. Considering all possible hole locations, what is the volume of the region in space that water can reach as it flows out through these holes?

QUESTION 2 COMING UP



QUESTION 2

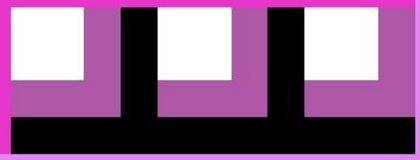


In the 18th century, physicists like Maupertuis and Euler sought a deeper principle governing the motion of objects. According to a famous principle in classical mechanics, every object follows a path that minimises, or more generally, makes stationary, a certain well-defined quantity. What is this quantity?

QUESTION 3 COMING UP



QUESTION 3



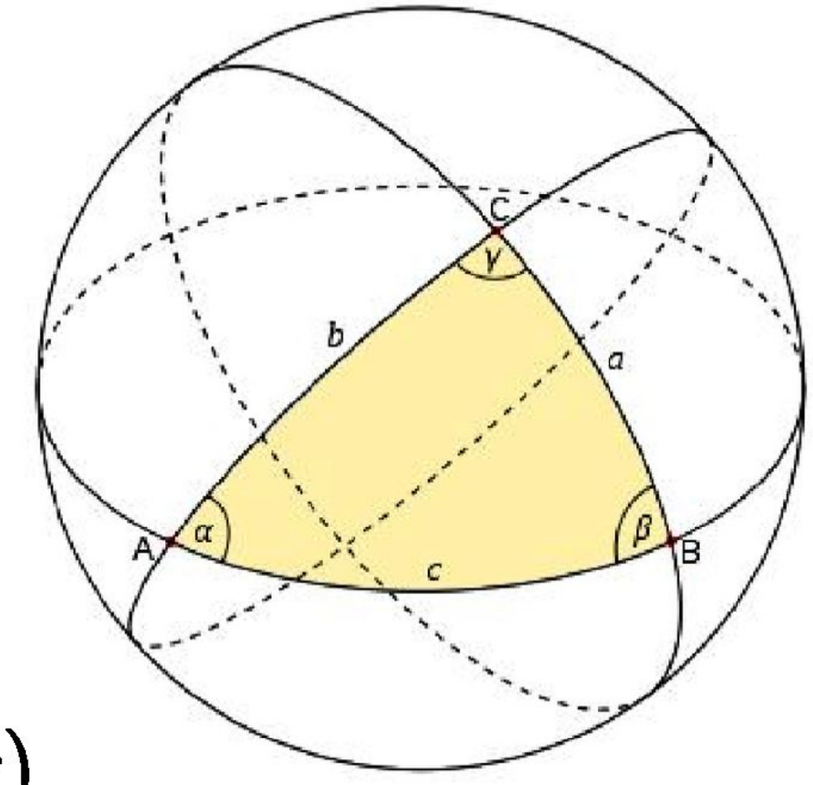
A stone is projected from a point on the ground. The projection is such that it would hit a bird stationary on the top of a telegraph post of height h, and this trajectory would achieve a maximum height of 2h above the ground. If, at the instant of projection, the bird were to fly away horizontally from the post with a uniform speed, find the ratio between the horizontal velocities of the bird V_b and the stone V_{sx}, if the stone still hits the bird while the stone is descending.

QUESTION 4 COMING UP



QUESTION 4

If a charge is kept on the vertex of a regular tetrahedron, find the flux passing through the face opposite to the vertex



It is given area of spherical triangle is $R^2 (\alpha + \beta + \gamma - \pi)$

QUESTION 5 COMING UP



QUESTION 5



Three balls of masses m_1, m_2, and m_3 are at the vertices of an equilateral triangle of side d. The system is rotating in free space in such a way that, under the mutual gravitational interaction of the three particles, the system is neither expanding nor contracting.

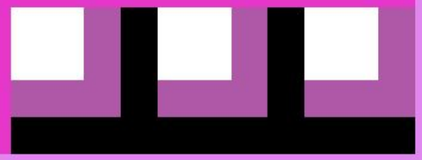
Find the angular velocity of this rotation.

The universal gravitational constant is G.

QUESTION 6 COMING UP



QUESTION 6



In 1696, Johann Bernoulli issued a challenge to the greatest mathematicians of Europe, confident that it would take them a considerable amount of time to solve. When Isaac Newton received the problem, he had already spent a long day working at the Royal Mint. Despite being exhausted, he sat down that evening and worked on the challenge. By the next morning, he had found a solution overnight. Bernoulli, upon seeing the solution, reportedly remarked that he recognised the lion by its claw. A solution to this problem uses Snell's Law. What was the problem that Newton solved overnight?

QUESTION 7 COMING UP



QUESTION 7

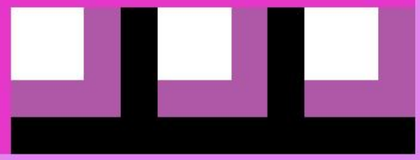


Consider a cannon kept at (0,0).
We are shooting balls with a constant speed v but at variable angles (from 0 to π) from the positive x-direction.
All the paths of the projectile are enclosed in an envelope which is a conic. This conic is X, and Y is the height above the ground of its focus.
Find X and Y

QUESTION 8 COMING UP



QUESTION 8



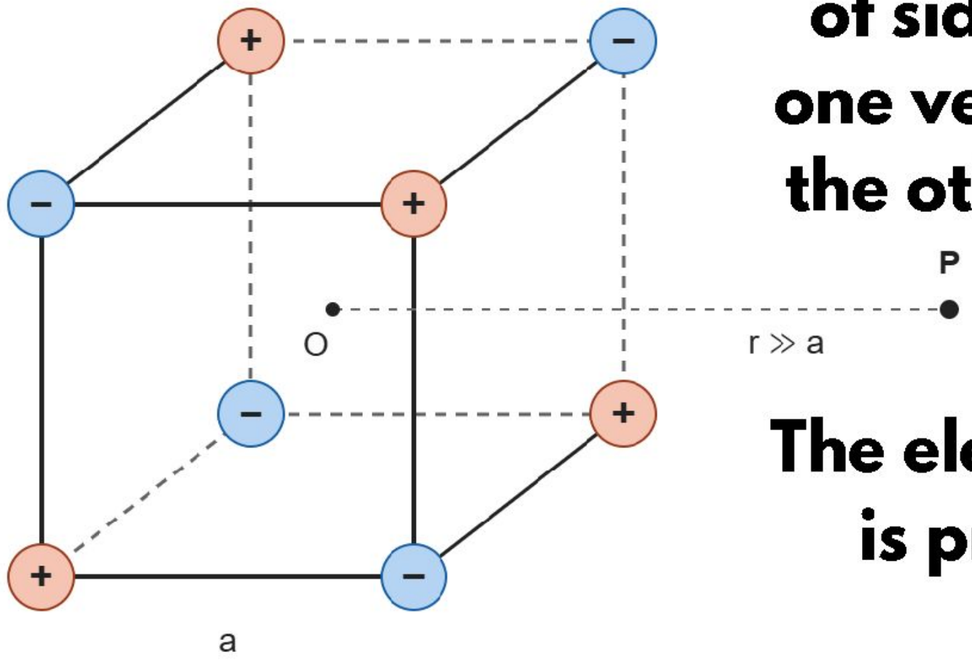
Consider n thermally insulated bodies with constant heat capacities C1, C2 . . . Cn, initially at absolute temperatures T1, T2 . . . Tn, respectively. The bodies are arranged in a sequence and connected by ideal, reversible Carnot engines, with each engine operating between adjacent bodies. The engines extract work as heat is transferred between the bodies. The process continues reversibly until all the bodies reach a common final temperature T.

Find an expression for the final temperature T in terms of the initial temperatures and heat capacities.

QUESTION 9 COMING UP



QUESTION 9



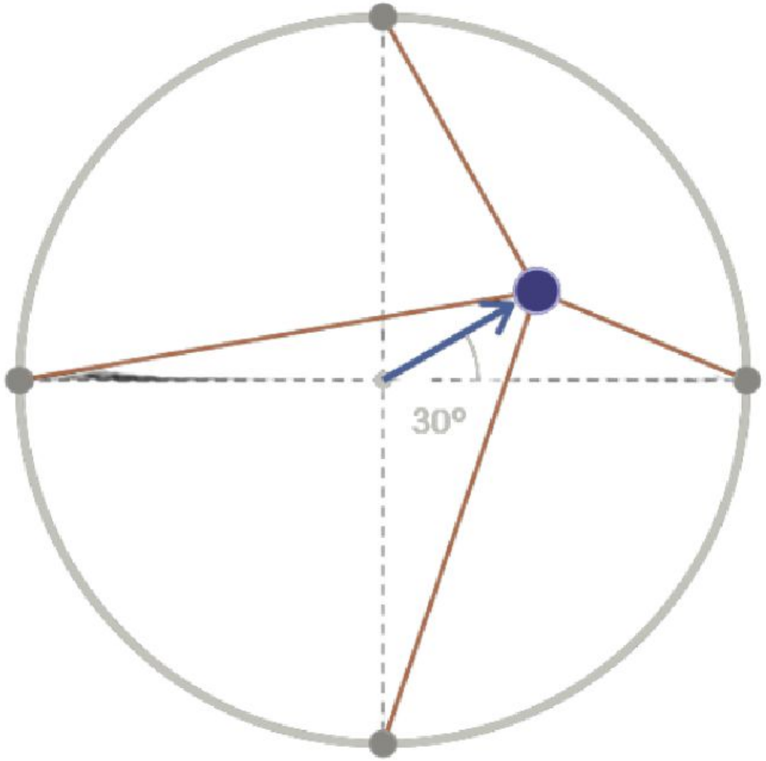
Consider charges +q and -q arranged on the vertices of a cube of side a such that at each edge, one vertex has a charge of +q and the other vertex has a charge of -q.

The electric field due to this system is proportional to $1/r^n$ when r >> a. Find n.

QUESTION 10 COMING UP



QUESTION 10

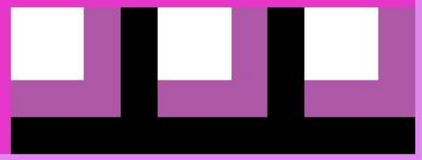


AB and CD are perpendicular diameters of a circular frame of mass 2m. Four elastic cords of force constant K and almost zero relaxed lengths are connected from point A, B, C and D to a bead at the centre of the ring which is free to move. Find the time period of oscillation if the bead is moved by a small distance at angle of 30 degrees from AB.

QUESTION 11 COMING UP



QUESTION 11



Consider masses m1 and m2 connected by a string on an elliptical pulley with coefficient of friction μ and with lengths of the semi-major axis and semi-minor axis being a and b, respectively. Suppose m1 > m2 and m1 is heavy enough such that the masses are moving. Find the acceleration of the masses.

(The string is in contact only with upper half of the pulley's circumference)

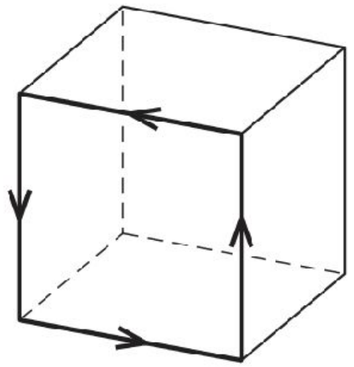
QUESTION 12 COMING UP



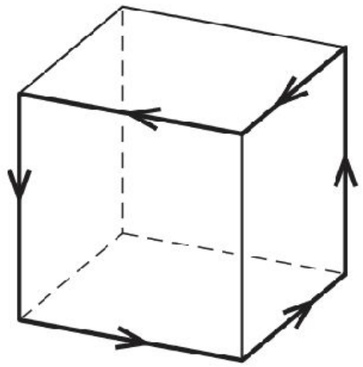
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Three metal wires of length 2a, 4a and 6a are placed along the edges of a cube of side a as shown. The self inductances are L1, L2 and L3 respectively. Find L3 in terms of L1 and L2.

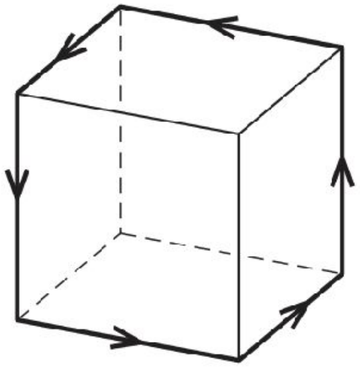
$a)$



$b)$



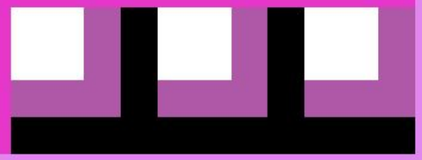
$c)$



QUESTION 13 COMING UP



QUESTION 13

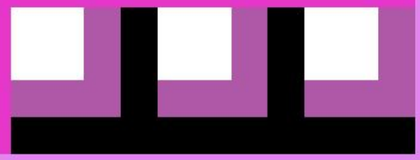


A long, thin-walled copper cylindrical conductor has a mean radius 20m and a wall thickness 1 mm. A uniform total axial current of $\pi \times 10^7$ A flows through the cylinder. Assuming the material remains within its elastic linear range with a Young's modulus of 100 GPa and neglecting end effects, calculate the amount by which the radius of the cylinder decreases in cm.

QUESTION 14 COMING UP



QUESTION 14

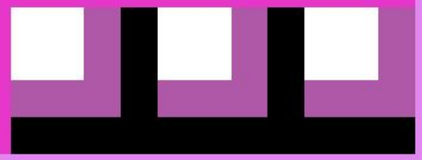


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Assuming all collisions between the balls and between the bottommost ball and the floor are perfectly elastic, determine the speed of the topmost ball after all collisions have taken place.

QUESTION 15 COMING UP



QUESTION 15



Consider an infinite, two-dimensional square grid network in which every branch consists of an identical resistor of resistance R.

Saksham modifies the network by changing a single branch: the direct connection between two adjacent nodes, A and B, is replaced with a resistor of resistance 2R, while every other branch in the infinite lattice remains unchanged at resistance R.

What is the net equivalent resistance R_{new} measured across nodes A and B in this modified network?

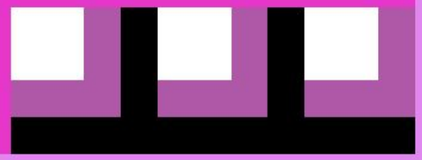
SECOND LOOK



QUESTION 1 COMING UP



QUESTION 1

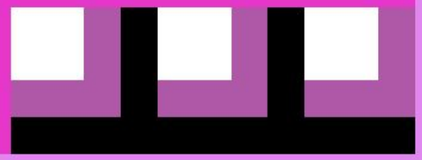


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QUESTION 2 COMING UP



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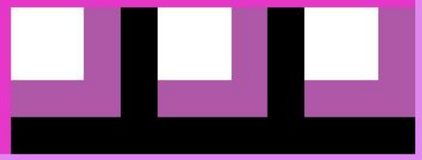


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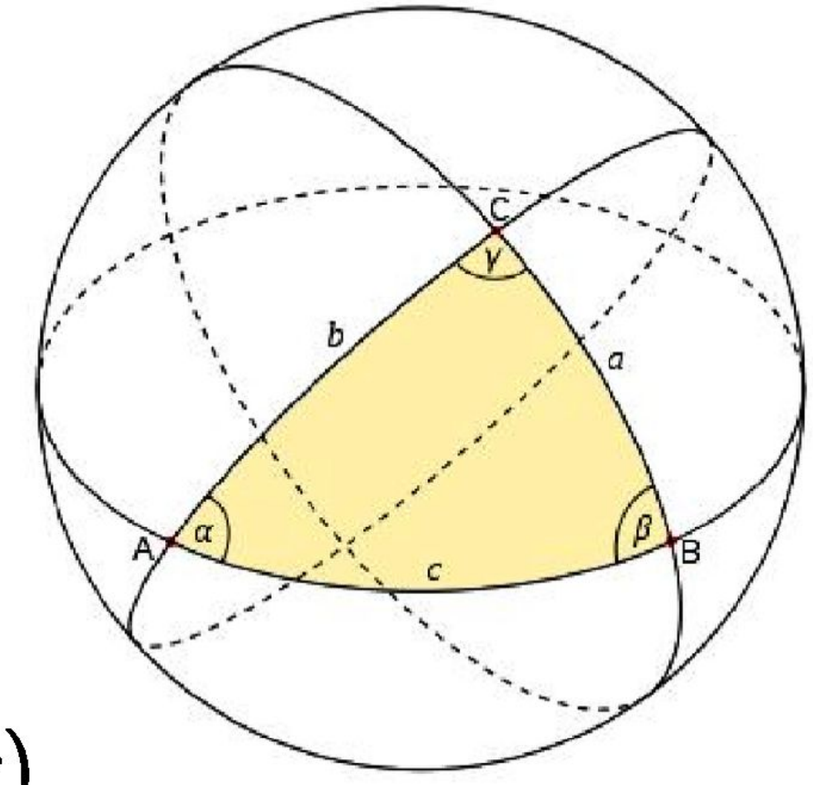
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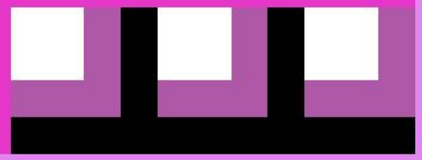
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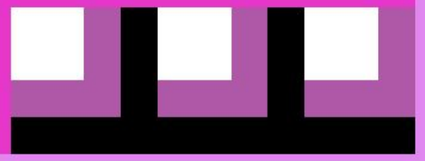


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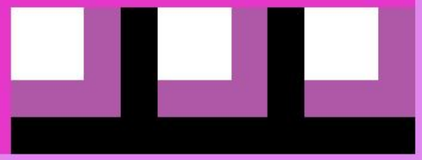


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QUESTION 8 COMING UP



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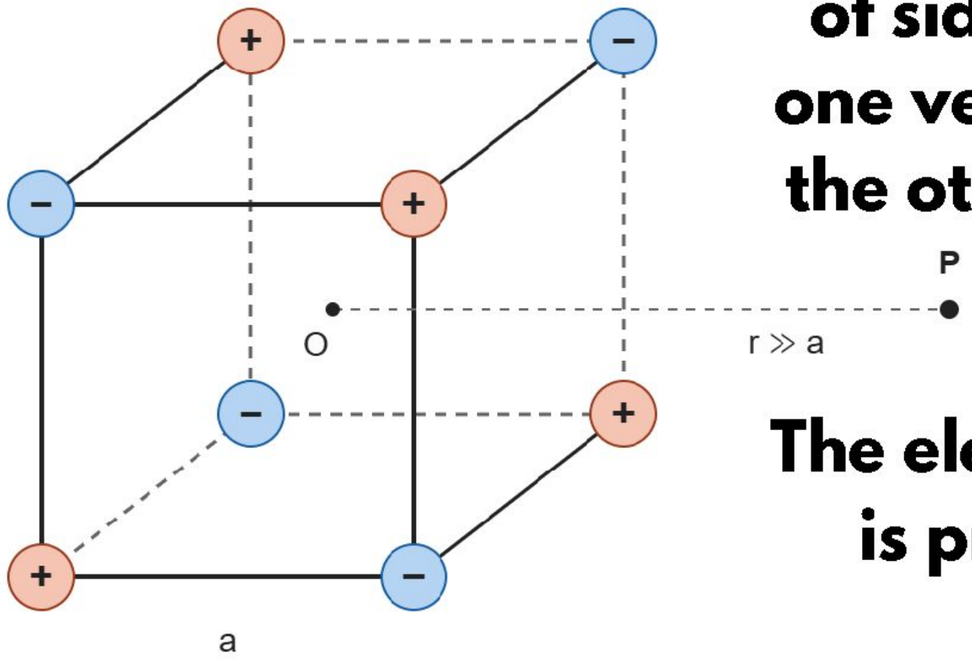
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QUESTION 9 COMING UP



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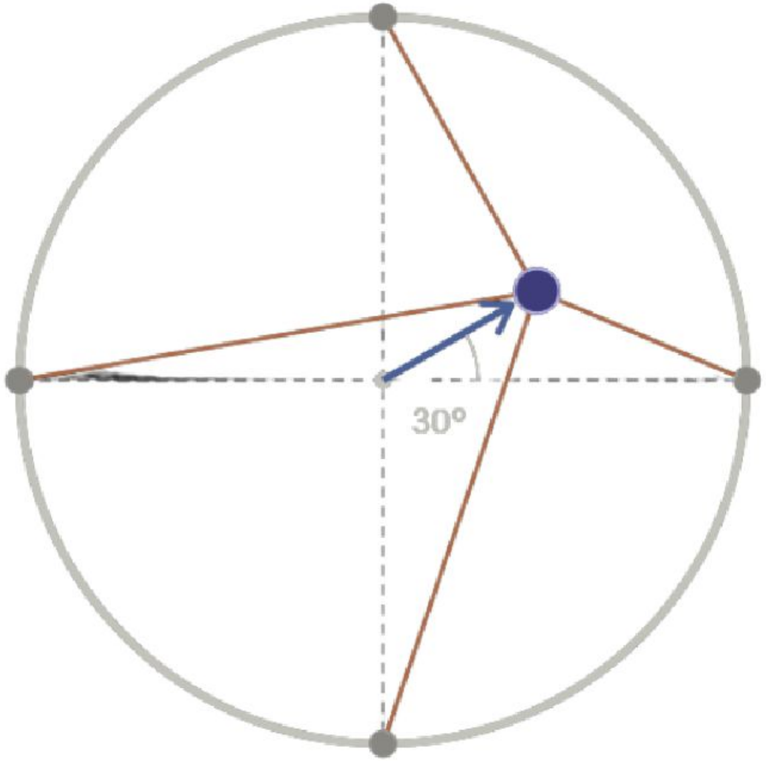
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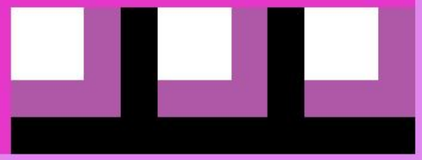


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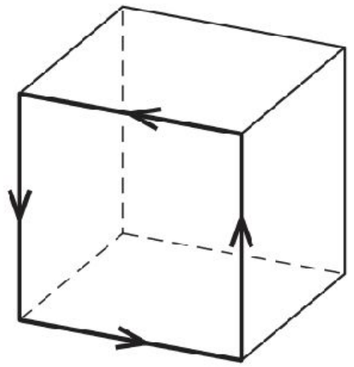
QUESTION 12 COMING UP



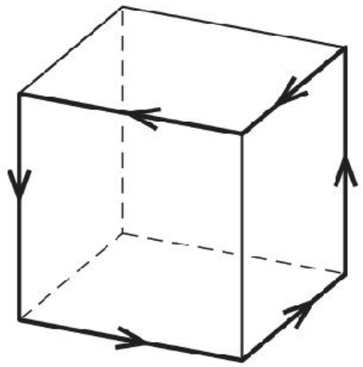
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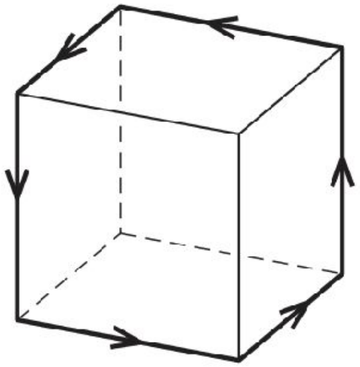
$a)$



$b)$



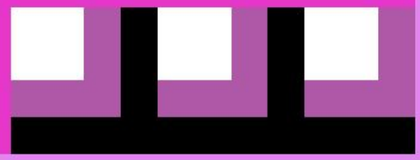
$c)$



QUESTION 13 COMING UP



QUESTION 13

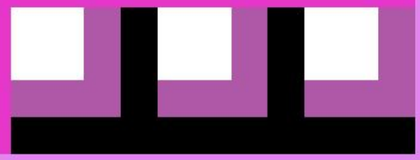


A long, thin-walled copper cylindrical conductor has a mean radius 20m and a wall thickness 1 mm. A uniform total axial current of $\pi \times 10^7$ A flows through the cylinder. Assuming the material remains within its elastic linear range with a Young's modulus of 100 GPa and neglecting end effects, calculate the amount by which the radius of the cylinder decreases in cm.

QUESTION 14 COMING UP



QUESTION 14



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Assuming all collisions between the balls and between the bottommost ball and the floor are perfectly elastic, determine the speed of the topmost ball after all collisions have taken place.

QUESTION 15 COMING UP



QUESTION 15

refractive index in a medium varies as $n(r) = 2an_0/r$ for r ≤ a and n(r) = n0 for r > a, n0 > 1 where r is the distance of a point from origin . A ray starts at (b,0) for b < a at an angle θ from the positive x direction. Find the condition on the minimum value of theta such that total internal reflection happens somehwere in the ray's trajectory.

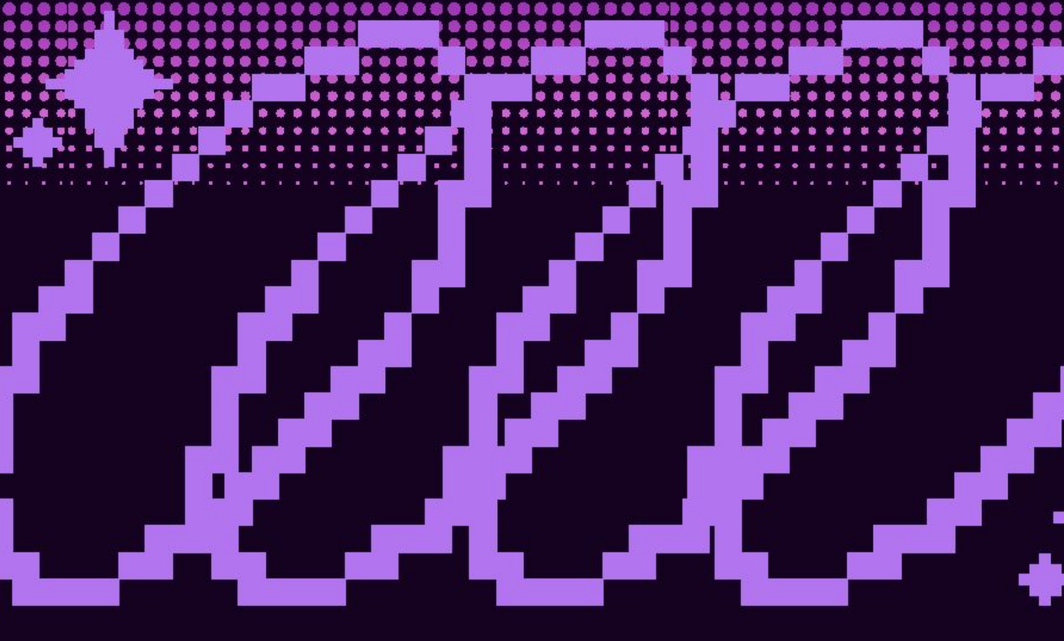

AND WE
ARE DONE

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BAZINGA! PHYSICS



The answers are coming

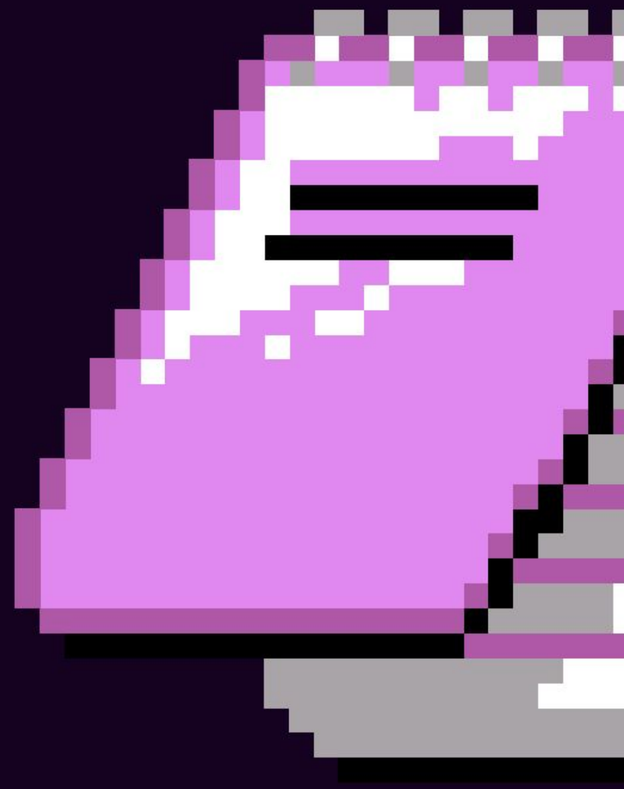
QUESTION 1



ANSWER

$$V = \pi RH^2 + \pi H^3/3$$

Hint - the envelope is a frustum

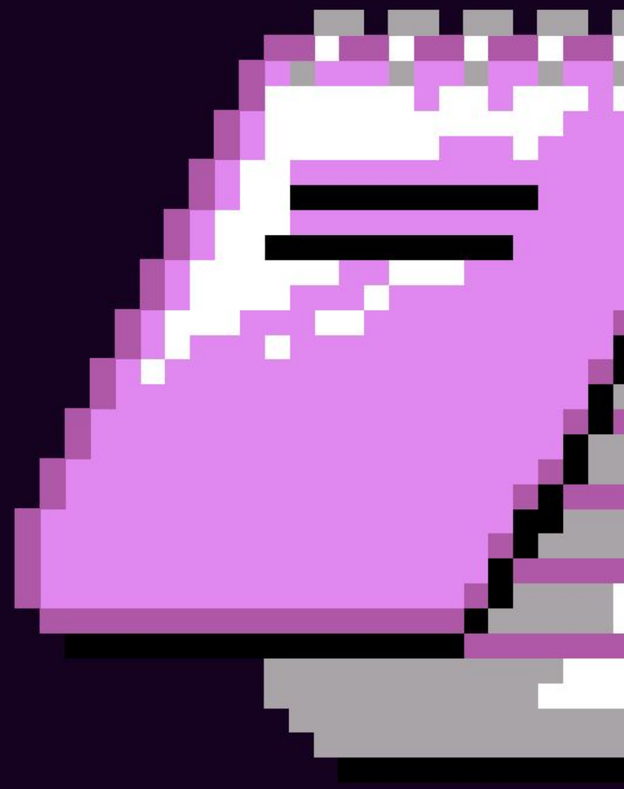


QUESTION 2



ANSWER

ACTION

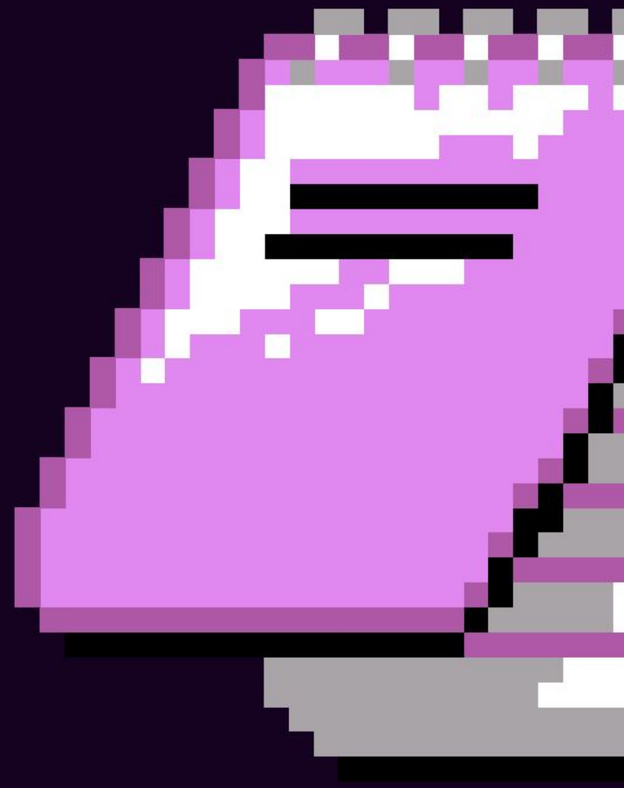


QUESTION 3



ANSWER

$$2(\sqrt{2} - 1)$$



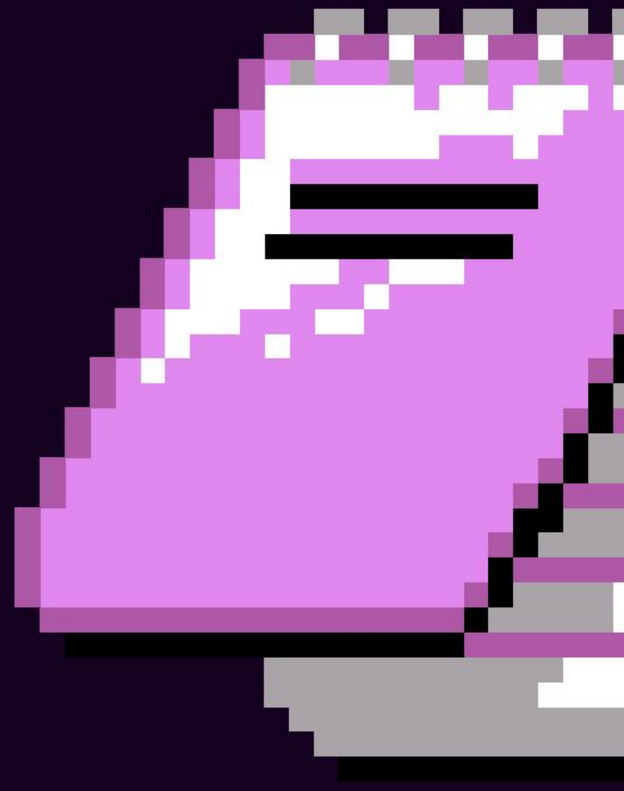
QUESTION 4



ANSWER

$$\frac{q}{4\pi\epsilon_0}(3cos^{-1}(1/3) - \pi)$$

Hint - the angle are angle between planes of tetrahedron

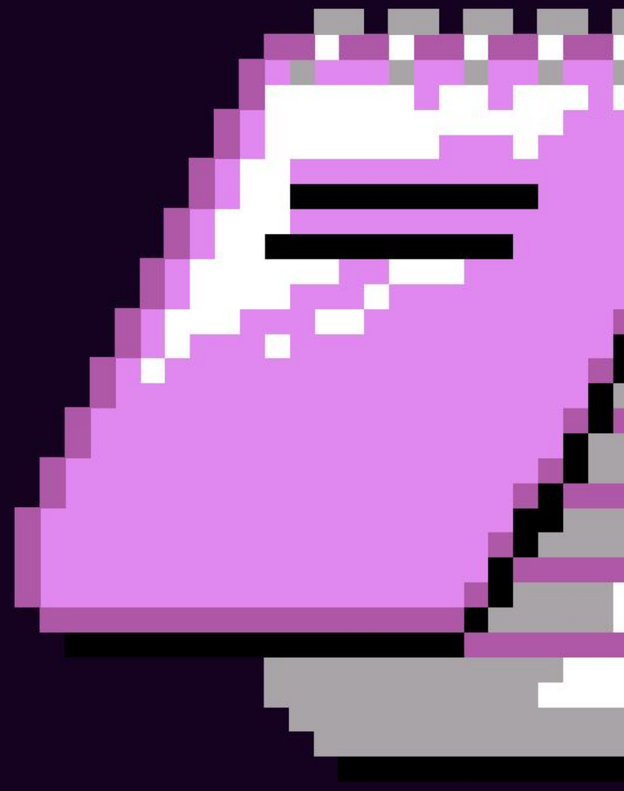


QUESTION 5



ANSWER

$$\sqrt{\frac{G(m_1 + m_2 + m_3)}{d}}$$

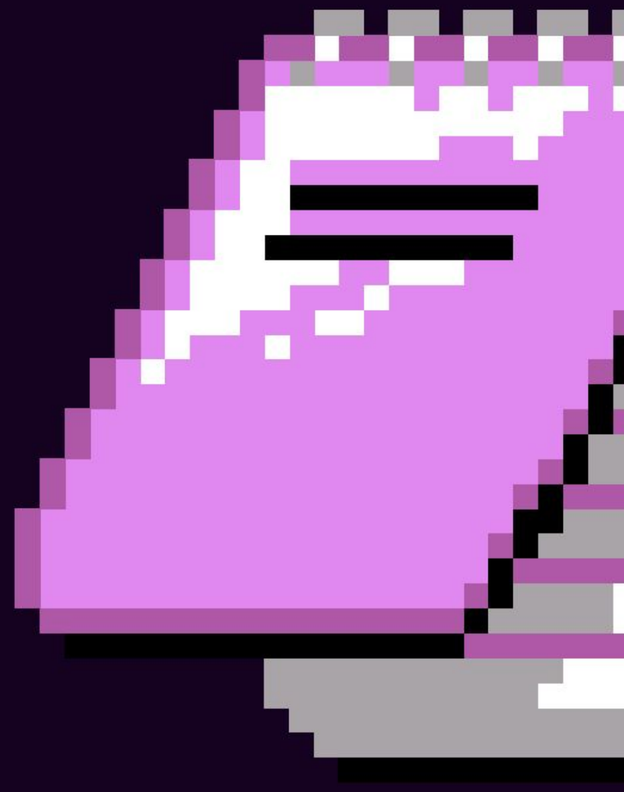


QUESTION 6



ANSWER

brachistochrone problem



QUESTION 7

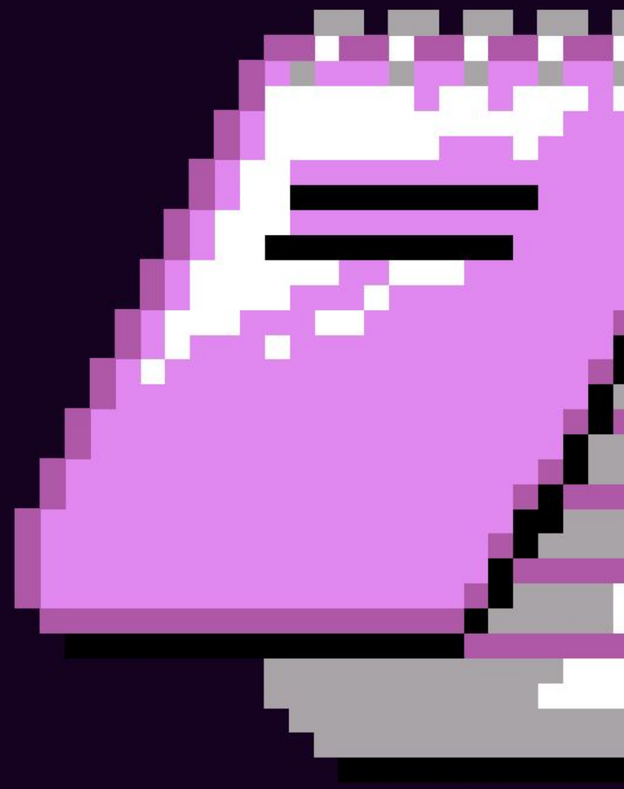


ANSWER

X - parabola

Y - 0

Hint - real solutions for quadratic in sec(theta)



QUESTION 8

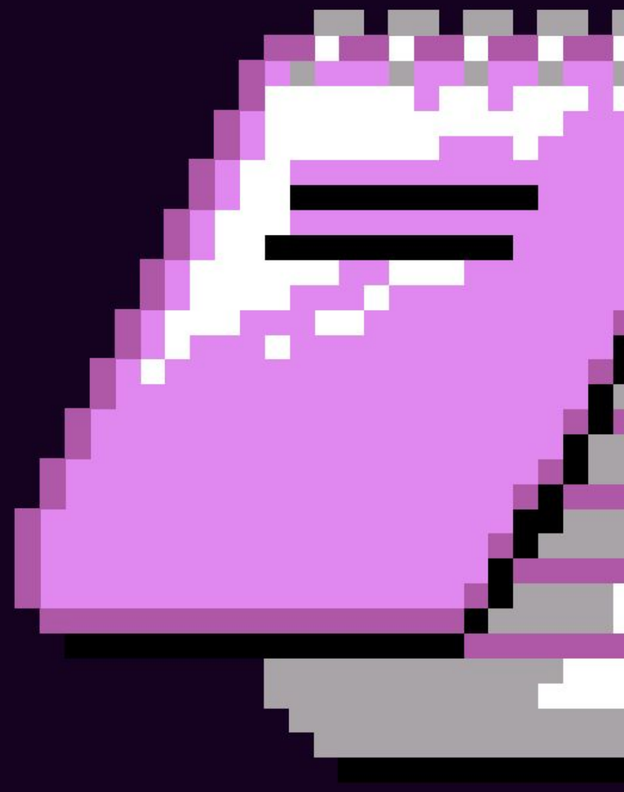


ANSWER

$$(T_1^{C_1} \dots T_n^{C_n})^{1/(C_1+C_2+\dots+C_n)}$$

Hint - change in entropy of universe is 0)

PS - you can prove weighted AM-GM inequality via this result ;)



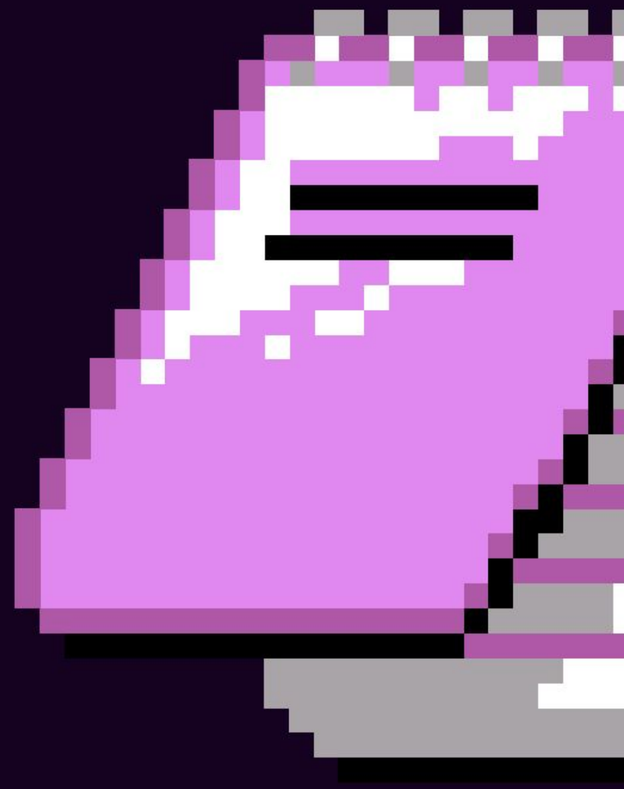
QUESTION 9



ANSWER

5

Hint- Generalise results obtained for dipoles



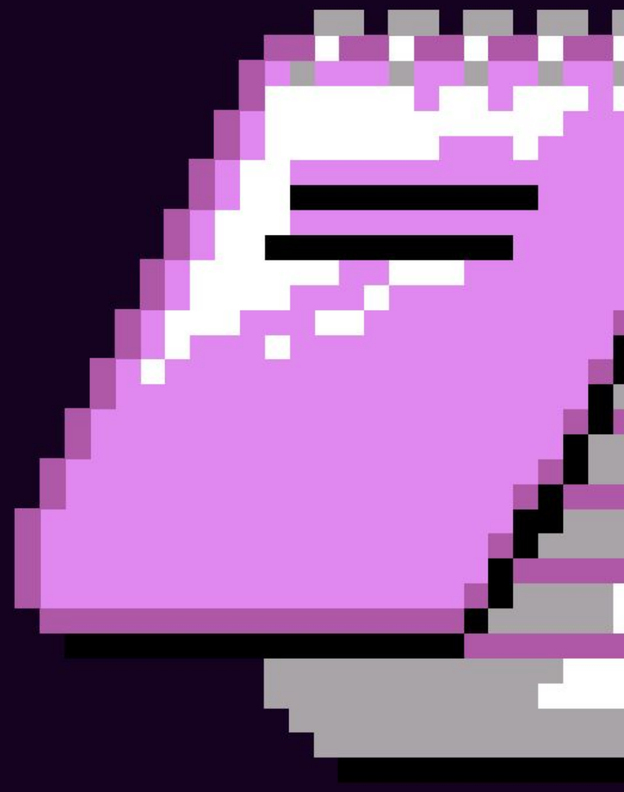
QUESTION 10



ANSWER

$$2\pi\sqrt{\frac{m}{6k}}$$

Hint- Use vectors to find net force



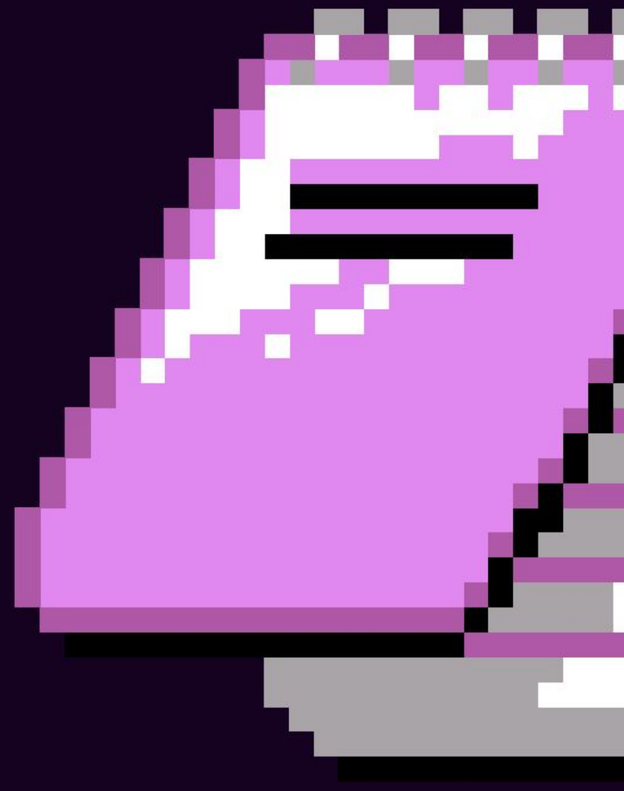
QUESTION 11



ANSWER

$$\left(\frac{m_1 - m_2 e^{\mu\pi}}{m_1 + m_2 e^{\mu\pi}}\right) g$$

Hint- The shape does not matter; the angle does



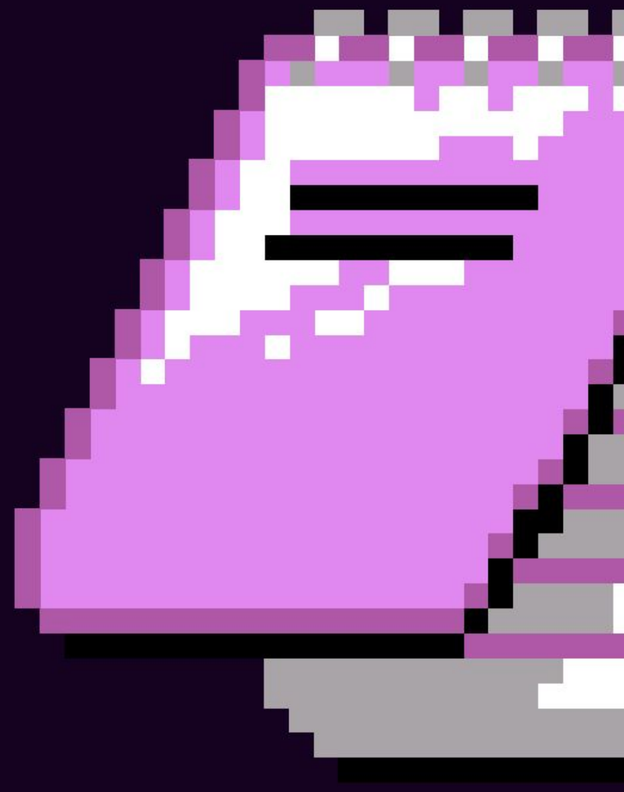
QUESTION 12



ANSWER

$$3(L_2 - L_1)$$

Hint- complete the squares



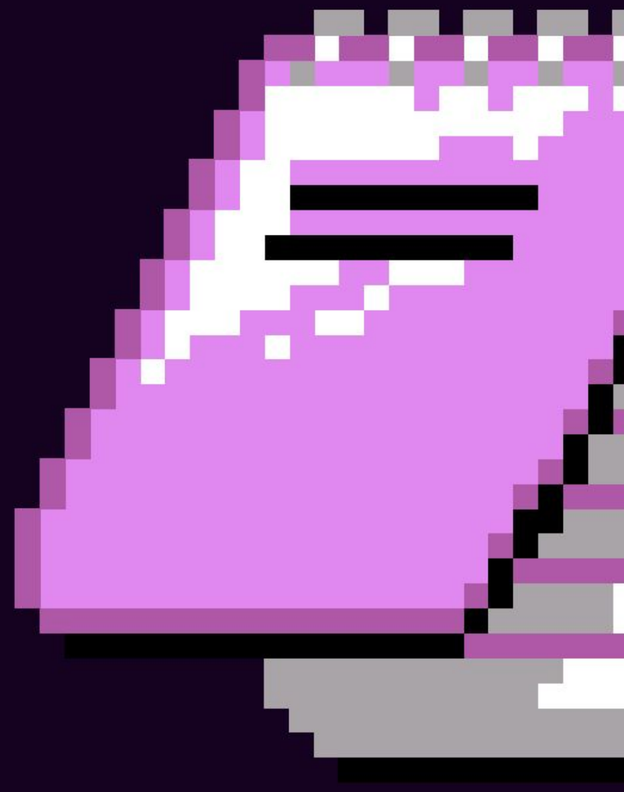
QUESTION 13



ANSWER

5π

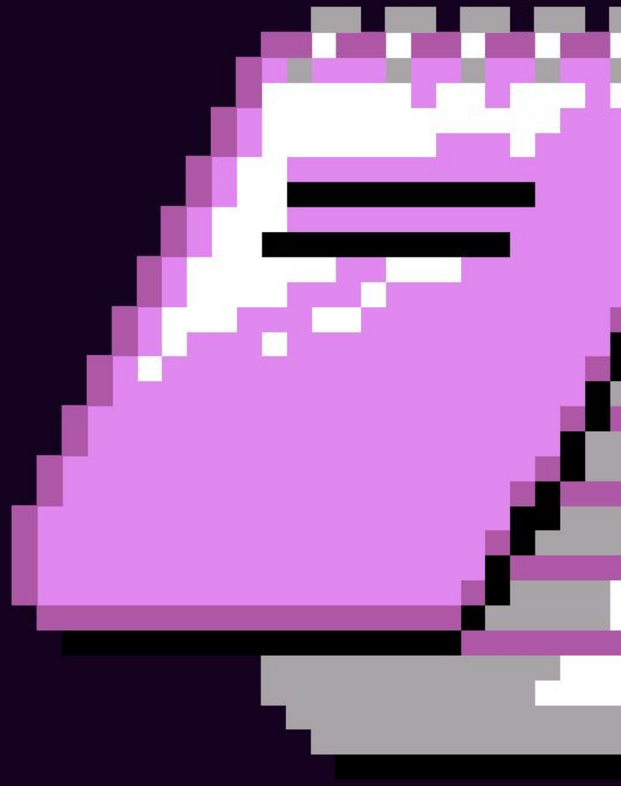
Hint- use magnetic pressure



QUESTION 14



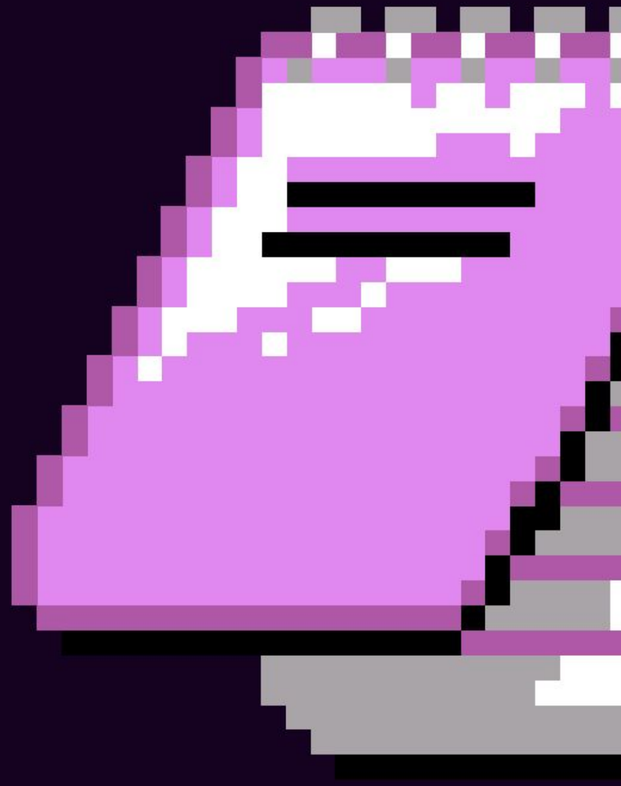
ANSWER



QUESTION 15



ANSWER



THANK YOU