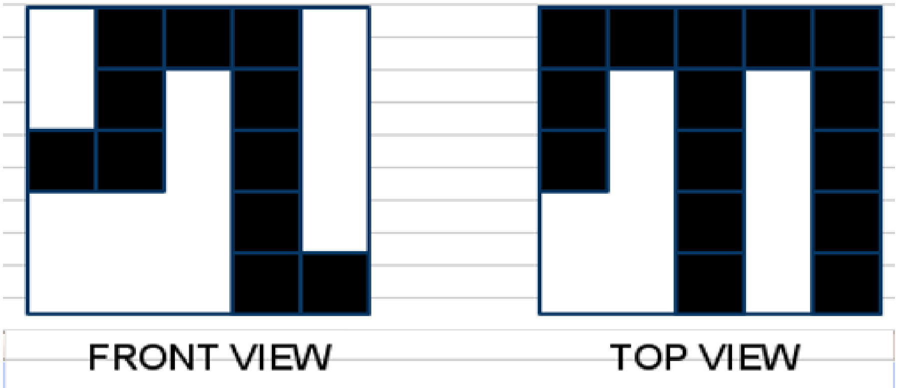
Eureka! Challenge Series :-

Q.1. Following are the front and top views of an object that was created by removing unit cube-pieces out of a 5x5x5 wooden block. What English letter does this object resemble, when seen from the right side ?



ANSWER: The side-view of the object resembles the letter 'E' .

Q.2. A and B are playing a game. There are 50 coins of different denominations placed in a straight line. A and B have alternate turns. In each turn, they can choose a coin from either end of the pile. At the end, the player with the maximum sum wins. Show that the player who starts first can play so as to never lose.

ANSWER: Number the coins 1 to 50. The player who starts first (say player A) should count the sum of coins at all the odd places, and separately the sum of coins at even places. If the odd sum is greater, he should pick the coin no. 1 first. This will leave coins 2 to 50 for B. Whichever coin B picks, one odd numbered coin will be revealed which can be chosen by A in the next turn. In this way, A will have the sum of all odd numbered coins at the end, and shall be the winner.
If the even sum is greater, he should choose coin 50 first, then play similarly as above.
In case the odd and even sums are equal, A can still play out for a draw.

Q.3. There are N petrol pumps in a circle which have just enough fuel in total for a car with no fuel to go around the circle once. Prove that if the car starts at the right pump, it can always go around the circle.

ANSWER:
Start from a petrol pump, say A-0. Keep moving anti-clockwise , refuelling at any stations encountered, until you run out of fuel. The moment you run out of fuel, jump to the next petrol pump ahead (A-1) and continue moving. In this way, you can trace a path all the way around the circle. Finally, one of 2 things will happen - either you will run out of fuel just before A-0 , or you will be able to reach A-0 from an earlier pump. The first case is impossible, since it implies that the total quantity of fuel in all the pumps is less than sufficient to complete the circle (this can be easily checked) . Thus the second case is true, which implies that you can reach A-0 starting from an earlier pump, and hence go atleast as far as you could when you started at A-0. This argument can be repeated so long as one has not completed the entire path continuously.
(Note : This problem can also be solved using induction.)

Q.4. An infinitely long straight wire carries a slowly varying current I(t). Determine the induced electric field as a function of the distance s from the wire. What is the field at infinity ?
Your answer may seem wrong. What is the physical problem here ?

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$$

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i$$

ANSWER: 1) Electric Field varies as log(s).
2) This is a very peculiar problem. The electric field becomes infinite at infinite distance, which is impossible. The reason is the violation of the quasistatic limit of the biot savart law i.e. electromagnetic disturbances travel at speed c , not infinite.

Q.5. There are five holes arranged in a line. A hermit hides in one of them. Each night, the hermit moves to a different hole, either the neighboring hole on the left or the neighboring hole on the right. Once a day, you get to inspect one hole of your choice. How do you make sure you eventually find the hermit?

ANSWER: Number the holes 1 to 5. Since on each night the hermit moves to an adjacent hole, if he was in an even numbered hole on one day, he will be in an odd numbered one on the next day. The combination 432432 will work (there are other combinations too)
Assume that the hermit was in an odd numbered hole before starting. Then the next day, he will be in an even numbered one, so we check hole 4 first . Verify that the combination 432 will catch him. In case the hermit was in an even numbered hole at the start, he will be in an odd numbered one after 3 days,so we will catch him in the next iteration.