General Statistics:

In this fourth competition, 653 teams (1126 students) from forty-eight schools registered for the contest and 579 teams actually wrote the contest, some as teams of one, but most as teams of two. Of the teams who wrote, 3% were in grade 10 or below, 46% were in grade 11 and 51% were in grade 12.

No team had a perfect score of 10. The average score was 4.

Students competed in two categories – Grade 11 or below, and Grade 12. Where there was a tie score, prize winners were determined by elapsed times. Virtually all teams completed the test in under 75 minutes and most finished in less than 60 minutes.

Cash prizes of $100 per team were awarded to the top three teams in Grade 12 and the top three teams in Grade 11 (or below). Certificates of Honourable Mention were awarded to teams in Grade 12 who achieved a score of at least 8 and teams in Grade 11 (or below) who achieved a score of at least 7.

Answer, Success Rate and Statistics for each Question:

Question 1: Answer: A - 73% correct (B: 6%, C: 18%, D: 3%)

The horizontal and vertical motion of the softballs is independent. The initial velocity of the softball is given by the initial speed time the sine of the angle from the vertical. Therefore ball A has a greater initial velocity upward, and it will take longer for it to reach its maximum height and to return to the ground.

Question 2: Answer: C - 15% correct (A: 27%, B: 7%, D: 51%)

An object, such as a candle, emits light in all directions. More of this light will hit a large lens than will hit a small lens if they are in the same positions. Since the large and small lenses have the same focal lengths, they both form images in the same position. However, the large one will focus more light onto the image, and the image will be brighter.

Question 3: Answer: D – 21% correct (A: 8%, B: 17%, C: 54%)

When the switch is initially open, bulbs A and B glow, but bulb C does not, because bulb C is not in a closed circuit. However, the tops of both batteries are joined and therefore have the same potential. Since the batteries are identical, the potential at the bottom of both batteries is the same. Since these are joined to the two sides of the open switch, there is no potential difference between the two sides of the switch. Once the switch is closed, there is still no potential difference across it, so no current flows through the switch and through bulb C.
Therefore bulb C still doesn’t glow. The potential across each of bulb A and B are still the potential difference of each identical battery, so they continue to glow just as before.

Question 4: Answer D – 57% correct (A: 15%, B: 23%, C: 5%)

An action-reaction pair of forces in Newton’s 3rd Law represents the interaction of two bodies. They are the force exerted by body 1 on body 2 and the paired force exerted by body 2 on body 1. These two forces are equal and opposite. Therefore, for the force exerted by the snow (ground) on sled due to friction, the Newton’s 3rd Law pair is the force exerted by the sled on the snow due to friction.

Question 5: Answer B - 26% correct (A: 35%, C: 5%, D: 34%)

5. The average acceleration is a vector defined as final velocity vector minus the initial velocity vector, all divided by the elapsed time. Here this gives a vector pointing east minus a vector of equal length pointing north. Thus the average acceleration vector points southeast.

Question 6: Answer C – 29% correct (A: 42%, B: 8%, D: 21%)

6. Waves on a string simply add together. This is called the principle of superposition, and results from the fact that the wave equation is a linear equation. After 4 s, each of the two pulses will have moved 4 m in the direction of the respective arrows. They will then partially overlap. Add the pulses together, and the net pulse looks like C.

Question 7: Answer: B – 50% correct (A: 19%, C: 22%, D: 9%)

A soccer field is approximately 100m by 50m. This is 5000 m² x (100 cm/m)² = 5x10⁷ cm². In each square cm of a healthy lawn, there are 10-20 blades of grass. This gives (5 to 10) x10⁸ blades of grass. This is close to 10⁹ (B). To get (A) would require a field 10m by 5m with 1 blade of grass per cm². To get (C) would require a field 1km by ½ km with 100 blades of grass per cm². Both of these are clearly wrong.

Question 8: Answer: A – 33% correct (B: 13%, C: 34%, D: 20%)

Energy is a scalar (number), not a vector. Work is a scalar too. The work-energy theorem states that the work done (on the puck) is equal to the change in kinetic energy. This is the difference between two numbers, the final and initial kinetic energy.

Question 9: Answer: C – 41% correct (A: 17%, B: 11%, D: 31%)

In this question the total magnetic field is equal to the Earth’s magnetic field plus the magnetic field due to the current in the power line running overhead. The magnetic field due to the current in the power line falls off very quickly as the distance to the power line increases. Compared to the Earth’s field, the field due to the power line is very weak. If the power line runs north-south, then the right-hand rule shows the direction of the magnetic field due to the north-south current
in the power line is east-west. It will oscillate at 60 Hz (because it is an ac current in the wire). The two fields add as vectors. The needle might be deflected a tiny amount from the direction of the constant Earth’s field, and wiggle a bit, but would continue to point north.

Question 10: Answer B – 33% correct (A: 9%, C: 41%, D: 17%)

10. If both of the twins ran off the opposite ends of the rail car with the same speed at the same instant, then their momenta would be equal and opposite and would sum to zero. Since the entire system of the car plus two twins started with zero momentum, conservation of linear momentum would require that the rail car also has zero momentum at the end and would be motionless. However, this is not what happens. First, one twin stays on the rail car while the other jumps off the east end. Momentum is imparted to both the remaining twin and the rail car, and they travel to the west. Now the second twin runs off the west end, running with the same speed. This time, essentially the same amount of momentum is imparted to the rail car alone, so that it gains more momentum directed to the east than it had when it was moving to the west. Therefore, it ends up moving very slowly to the east.