SRI LANKAN PHYSICS OLYMPIAD COMPETITION – 2006

Time Allocated : 02 Hours
Calculators are not allowed to use.

Date of Examination : 25 – 03 – 2006   Index No. : ………………

Time : 9.30 a.m. - 11.30 a.m.

INSTRUCTIONS

- Answer all questions
- There are two parts (A and B) in this paper.
- Part A contains 20 multiple choice questions. Your answer to each question must be marked on the body of the question paper itself.
- Select the single answer that provides the best response to each question. Please be sure to use a pencil and underline the response corresponding to your choice. If you change the choice of an answer, the previous underline mark must be completely erased.
- Your score on this multiple choice section will be your number of correct answers. There is no penalty for guessing. It is to your advantage to answer every question.

- Part B contains two semi – structured type questions.
- Use the paper provided to do all the calculations in part A as well as in part B.
- Write down the corresponding final expressions or the final numerical answers for part B questions on the last page attached in the question paper itself.
- At the end of the exam handover the question paper with your marked responses together with the final answer sheet.
- Handover the papers used to workout the problems in Part B separately with your index number written on each paper.
- Do not detach any sheet from the question paper.

$g = 10 \text{ m s}^{-2}$

PART A

1. A person standing on top of a tall building throws a ball of mass *m* straight up and a second ball of mass *2m* straight down with identical speeds. Which of the following statements is true? (Neglect air resistance)

    (1) The ball that was thrown upward hits the ground with greater speed than the ball that was thrown downwards.

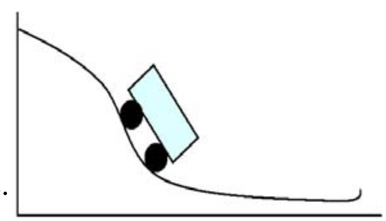
    (2) The ball that was thrown downwards hits the ground with greater speed than the ball that was thrown upwards.

    (3) Both balls hit the ground with the same speed.

    (4) Both balls hit the ground with the same momentum.

    (5) Both balls exert the same force on the Earth when they hit.

2. A trolley rolls down a slope as shown below. Neglecting friction, as the trolley rolls beyond the position shown, what happens to its speed and the magnitude of its acceleration along the slope?



    (1) Both decrease.

    (2) Both remain constant.

    (3) The speed increases, but the acceleration decreases.

    (4) The speed decreases, but the acceleration increases.

    (5) Both increase.

3. Consider a bicycle that accelerates uniformly from rest on a horizontal surface. The only source of energy available to accelerate the bicycle is that provided by the rider of the bike. The bicycle is accelerated due to

    (1) the force applied by the rider's legs to the pedals.

    (2) the force applied by the chain to the wheel.

    (3) the force applied by the wheel to the road.

    (4) gravity.

    (5) friction between the road and the wheels.

4. A spear gun uses a spring as a launching mechanism. The gun fires a spear straight upwards to a height of 36 m. If the same spear is reloaded in the gun, but the spring is now extended only two thirds as much as in the previous situation, the spear attains a height of approximately:

(1) 36 m.

(2) 24 m.

(3) 18 m.

(4) 16 m.

(5) 9 m.

5. Two wires, made of same material, one thick and the other thin are connected to form one composite wire. The composite wire is subjected to the same tension throughout. A wave travels along the wire and passes the point where the two wires are connected. Which of the following changes at that point?

(1) Frequency only.

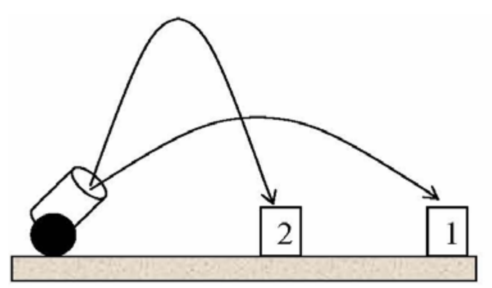
(2) Propagation speed only.

(3) Wavelength only.

(4) Both propagation speed and wavelength.

(5) Both frequency and Propagation speed.

6. A cannon simultaneously fires two identical cannonballs at targets 1 and 2 as shown below. If the cannonballs have identical initial speeds, which of the following statements is true? (Neglect air resistance)



(1) Target 1 is hit before target 2.

(2) Target 2 is hit before target 1.

(3) Both are hit at the same time.

(4) Which target gets hit first cannot be determined exactly.

(5) The kinetic energy of the cannonball that strikes target 1 must be greater than the kinetic energy of the ball that strikes target 2.

7. Two satellites A and B of the same mass are in circular orbit around the Earth. The distance of satellite B from the Earth's centre is twice that of satellite A. What is the ratio of the force acting on B to that acting on A?

(1) 1:8.

(2) 1:4.

(3) 1:2.

(4) 1:1

(5) There is no force on the satellites because they are in free fall.

8. Two bulbs, each with a resistance of 50 Ω, are connected in series. Each of the bulbs will burn if a power of more than 200 W is dissipated in it, what is the maximum voltage than can be applied to the circuit? (Neglect the internal resistance of the supply)

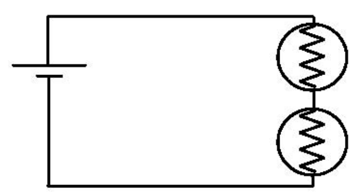
(1) 100 V.

(2) 140 V.

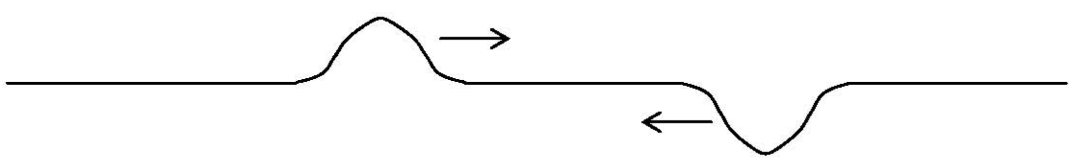
(3) 4 V.

(4) 8 V.

(5) 200 V.



9. Two symmetric, identical pulses of opposite amplitude travel along a stretched string in opposite directions as shown in the figure below. Consider the following statements.



(A). There is an instant when the string is straight.
(B). When the two pulses interfere completely, the energy of the wave is zero.
(C). There is a point on the string that does not move up or down.

Of the above statements

(1) Only (A) is true.

(2) Only (B) is true.

(3) Only (A) and (B) are true.

(4) Only (A) and (C) are true.

(5) All (A), (B) and (C) are true.

10. A hole is punched in the side of a bucket so that water flows out and follows a parabolic trajectory. If the container is dropped, falls freely accelerating under gravity, the water flow

(1) stops.

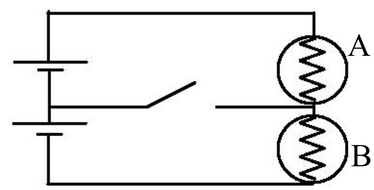
(2) follows a straight line trajectory relative to the falling bucket.

(3) follows an upward curving trajectory relative to the falling bucket.

(4) follows a downward curving trajectory relative to the falling bucket.

(5) decreases but continues to flow.

11. The light bulbs and the batteries in the circuit below are identical. When the switch is closed:



(1) Both go off.

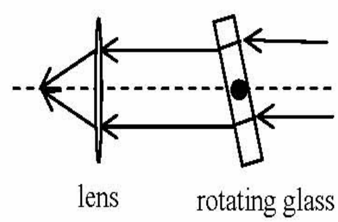
(2) The intensity of bulb B increases.

(3) The intensity of bulb A increases.

(4) The intensity of both increases by the same amount.

(5) Nothing changes.

12. A slab of flat glass, with parallel faces, is placed in the path of a parallel light beam before it is focused to a spot by a lens. The glass slab is rotated slightly back and forth from the vertical orientation, about an axis coming out of the page, as shown in the diagram. Which of the following statements is true regarding the focused spot?



(1) There is no effect on the spot

(2) The spot moves towards then away from the lens.

(3) The spot moves up and down parallel to the lens.

(4) The spot blurs out of focus.

(5) The spot dims.

13. The following household appliances are powered by the 240 V mains supply. Which has the greatest electrical resistance?

(1) A 3 kW heater.

(2) A 1 kW heater.

(3) A 1 kW iron.

(4) A 100 W incandescent bulb.

(5) A 25 W incandescent bulb.

14. An electrical power company has to decide whether they can transmit 2 kV power more efficiently through a single steel cable with cross sectional area 6 cm^2, or through two steel cables in parallel, each with cross sectional area 3 cm^2, or through three steel cables in parallel, each with cross sectional area 2 cm^2. What is the most efficient system?

(1) The three cable system.

(2) The two cable system.

(3) The one cable system.

(4) The most efficient system depends on the total current.

(5) They are all equally efficient.

15. A space walking astronaut, floating freely in space at rest relative to his rocket, watches the rocket's engine briefly ignite. The statements below refer to the change in the rocket's kinetic energy and momentum, and to the kinetic energy and momentum of the exhaust gases produced, as measured by the astronaut. Which one of the following statements is correct?

(1) The magnitude of the rocket's momentum is greater than that of the gases.

(2) The magnitude of the gases' momentum is greater than that of the rocket.

(3) The kinetic energy of the rocket is greater than the gases' kinetic energy.

(4) The kinetic energy of the gases is greater than the rockets' kinetic energy.

(5) The kinetic energy of the gases equals the rocket's kinetic energy.

16. A metal wire of cross sectional area 1 mm^2 has a conducting electron density of $6x10^{28}$ m^{-3}. The charge of an electron is $1.6x10^{-19}$ C. If the wire is carrying 1 A of current, what is the drift velocity of the conducting electrons along the wire approximately?

(1) 0.01 mm s^{-1}.

(2) 0.1 mm s^{-1}.

(3) 1 mm s^{-1}.

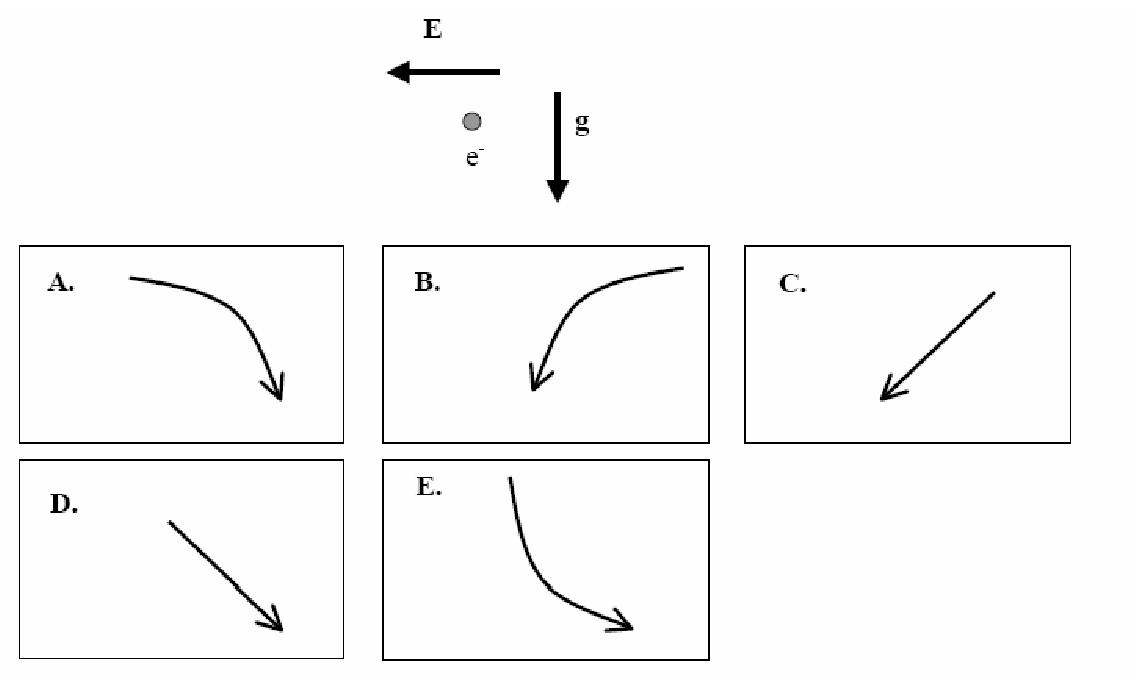
(4) 1 cm s^{-1}

(5) 1 m s^{-1}

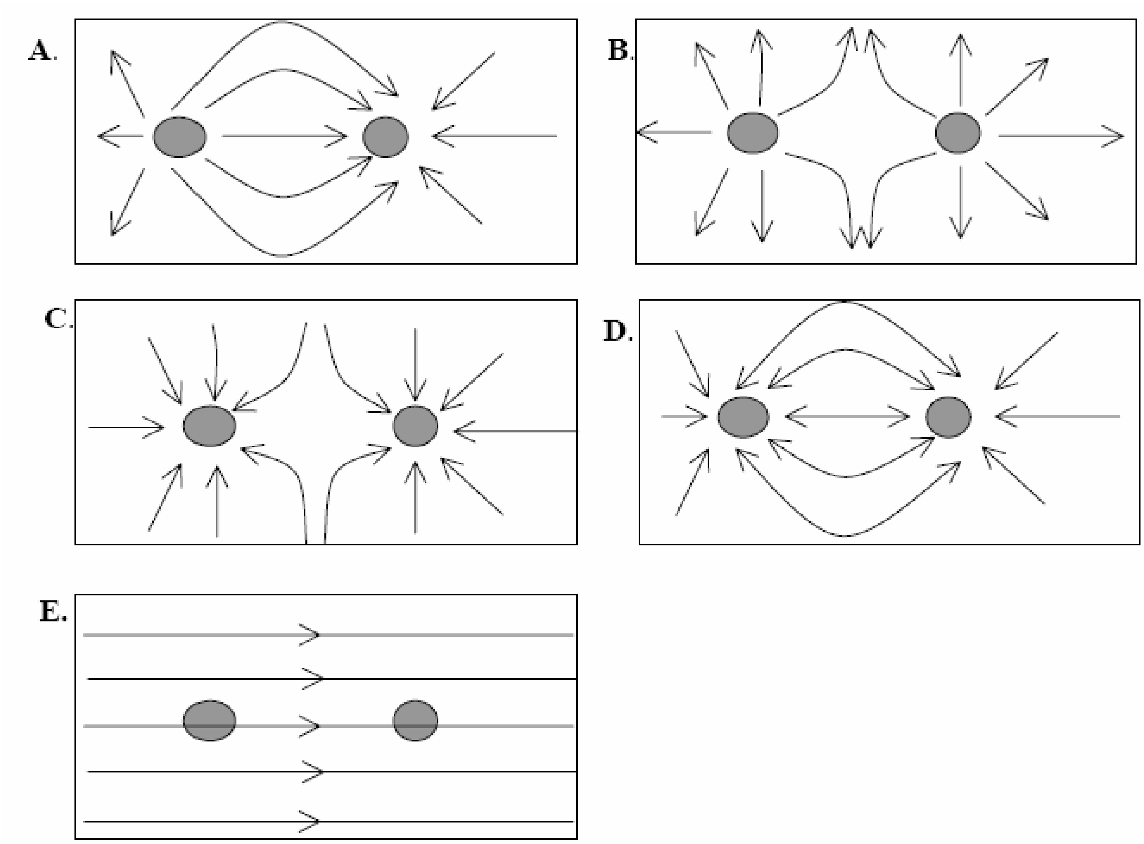
17. A large truck and a small car collide and stick together. Which one undergoes the larger change in momentum?

(1) The car
(2) The truck
(3) The momentum change is the same for both vehicles.
(4) Cannot tell without knowing the final velocity of the combined mass.
(5) Cannot tell without knowing the masses of the truck and the car.

18. A negatively charged object initially at rest is placed in a constant uniform gravitational field and a constant uniform electric field as shown in the figure. Which of the following paths best represents the shape of the trajectory of the object?



19. Which of the following diagrams correctly represents the gravitational field lines for a pair of masses placed in isolation?



20. Consider two hollow glass spheres, one containing water which fills up to about 10% of its volume, and the other containing a similar volume of mercury. In a zero gravity environment

(1) The water and mercury float freely inside the spheres.

(2) The water forms a layer on the glass while the mercury freely floats.

(3) The mercury forms a layer on the glass while the water freely floats.

(4) The water and mercury both form a layer on the glass.

(5) In each case a fraction will float and the rest will form layers on the glass.

PART B

(1) When a golf ball is hit by a club there are four phases to its motion: the impact, the flight, the bouncing, and the rolling.

Note that the parts of this question are independent - if you cannot answer something, try the next part. Throughout this problem ignore air resistance and any effects due to the ball's spinning.

The impact of the club on the ball is well approximated by a free body collision between the club head, of mass M, and the ball, of mass m. Momentum is conserved, but the kinetic energy is lost. The latter is described by the coefficient of restitution, e, which relates the difference between the club and ball speeds before the collision to that after the collision. Using subscripts c and b to denote the club and the ball, and subscripts i and f to denote the initial and final speeds: $v_{bf} - v_{cf} = ev_{ci}$

(a) The impact. Use this information to derive an expression for the speed of the ball after the collision v_{bf} in terms of the speed of the club before the collision v_{ci}, the coefficient of restitution e, and the masses M and m.

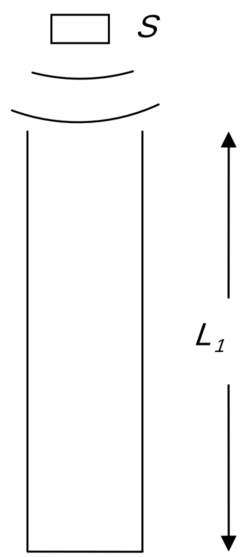
(b) The flight. Derive an expression for the horizontal flight distance of the ball (D), through the air until it hits the ground, in terms of v_{bf}, the acceleration due to gravity g, and the angle with the horizontal θ at which the ball is launched into the air.

(c) The bouncing. Denote the horizontal and vertical components of the ball's velocity just after rebounding from the ground the first time v_x and v_y. In terms of these, and g, derive an expression for the horizontal distance of the first bounce, (B_1).

(d) Assume that the horizontal component of the velocity does not change on rebound from the ground, but that the vertical component is halved at each bounce. Write down an expression for the total distance the ball bounces (B), from here onwards, in terms of v_x, v_y and g, assuming a large number of bounces.

(e) The rolling. Let it start rolling with the speed v_x and be stopped by the constant frictional force F. Derive an expression for the distance the ball rolls L in terms of its mass m, v_x and F.

(2) (i) The depth of an abandoned mine is to be measured using an audio oscillator which has an adjustable frequency output. When the oscillator (S) is placed at the top of the mine as shown, successive resonances at frequencies of 60 Hz and 84 Hz are observed. What is the depth (L_1) of the mine? (Neglect end corrections)



(ii) On another deep mine it was observed that resonance cannot be observed due its depth. In order to measure the depth of the mine, the oscillator was set to vibrate at 440 Hz and dropped it down the mine from rest. Just before the oscillator hits the base of the mine and got destroyed, a sound of 400 Hz was heard from the oscillator. How deep (L_2) was the mine?

(The speed of sound in air is 300 m s^{-1})