APEF

January 2000

Physics 12

MARKING GUIDE

NOVA SCOTIA
Department of Education

APEF PHYSICS EXAM
SELECTED RESPONSE SOLUTIONS
JANUARY 2000

1	C	9	D	17	C	25	D
2	C	10	B	18	A	26	C
3	B	11	A	19	B	27	B
4	C	12	D	20	A	28	B
5	A	13	B	21	D	29	D
6	A	14	C	22	C	30	A
7	A	15	A	23	A		
8	D	16	C	24	B		

1. a. In the equation $v_2 = v_1 + at$, the term 'at' must turn out to be what physics quantity? Explain. **(1.5 points)**
b. Assuming v_1 is equal to v_2, what does this tell us about the motion of the object? Explain your answer in with reference to the term 'at' . **(1.5 points)**

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Solution

a. Since 'at' must add to v_1 to get v_2 (structurally), it must give the unit of velocity. ....**1.5 points**

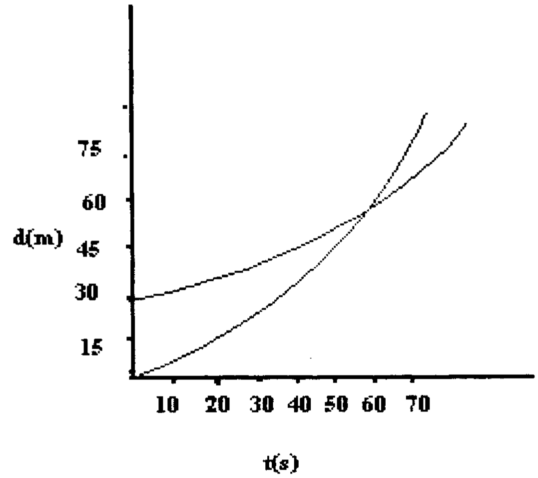
Alternately, the student may wish to do a dimensional analysis to get m/s.

b. This means that the increase in velocity due to acceleration is zero. ....**1.5 points**

2. The graph to the right shows two objects accelerating at the beginning of a race.

a. Give an appropriate interpretation of the vertical distance between the curves. **(1.5 points)**

b. What is the interpretation of the graph, in relation to the position of the objects, at the point the curves intersect? **(1.5 points)**



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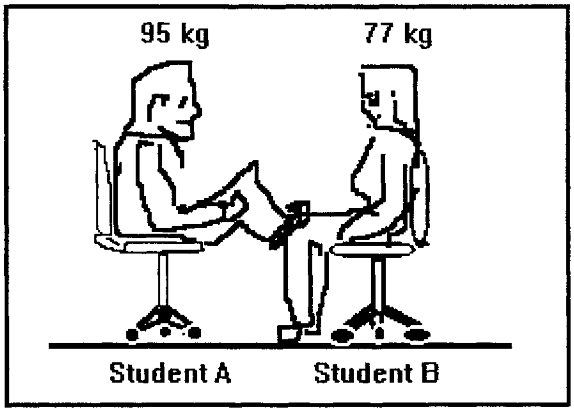
a. The vertical distance between the curves represents the decreasing distance separating the two objects.. **1.5 points**

b. The meeting point represents the point at which the object, that started from behind, catches the object that had the lead...**1.5 points**

3. Two students, student A who has a mass of 95 kg (including the chair) and a student B who has a mass of 77 kg (including the chair) sit in identical office chairs facing each other. Student A places his bare feet on student B's knees, as shown below. Student A then suddenly pushes outward with his feet, causing both chairs to move. Compare the acceleration of each student. Show your reasoning. **(3 points)**



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Solution

Both students will accelerate, the same force being applied to both (Newton's law of interaction).
.... **2 marks**
However, the less massive person will accelerate at the higher rate - 95/77 or 1.2 times
.... **1 mark**

4. Estimate to the nearest power of ten, the force of electrostatic attraction between two adults standing side-by-side if 2.0×10^{-6} C of charge has been transferred from one person to another. **(3 points)**

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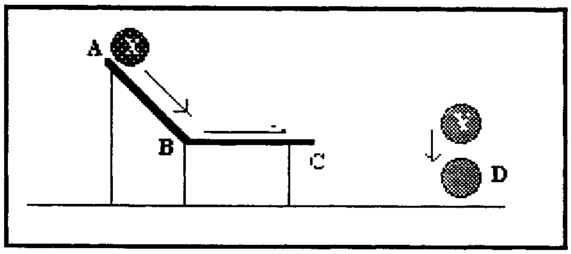
$F_e = kq_1q_2/d^2$ for the electrostatic force where the order of magnitude of the variables are 10^{10} for k, 10^{-6} for the charges, and 10^0 for the separation distance. Substituting in the equation .... **1 point**

$$F_e = kq_1q_2/d^2$$
$$= (10^{10})(10^{-6})(10^{-6})/(10^0)^2$$
$$= \mathbf{10^{-2}\ N}$$ .... **2 points**

(The answer can vary according to the distance choosen. Markers can use discretion.)

5.



Examine the diagram above. At the time ball X leaves the end of the ramp at point C, ball Y is dropped from the same height. When ball Y reaches point D, where would ball X be relative to the floor? Give your reasoning. **(3 points)**

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Ball X will be the same distance from the floor as Ball Y. .... **1 mark**
Although Ball X will take a parabolic path, it falls vertically at the same rate as Ball Y. The vertical and the components of Ball X are independent of each other........... **2 marks**

6. The centripetal acceleration required to keep an object moving in a horizontal circular path at constant speed is related to the velocity and the radius of orbit.

   a. To what is centripetal acceleration directly proportional? Explain. **(1 point)**
   b. If this variable to which centripetal acceleration is directly proportional were to triple, how would this affect the magnitude of the centripetal acceleration? Show calculations. **(2 points)**

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a. The centripetal force is directly proportional to the square of the velocity - $F \alpha v^2$.
.... **1 point**

b. The centripetal force would increase by 9 times......................................**1 point**

$F_1/(v_1)^2 = F_2/(v_2)^2$

$F_2 = F_1 (v_2)^2/(v_1)^2$

$= F_1 (3)^2/(1)^2$

$F_2 = 9 F_1$... **1 point**

7. To make an object of mass 'm' move at speed 'v' around a circular path of radius 'r', a centripetal force 'F' is required. Sketch the graph of the relationship between force and velocity. Explain this graphical relationship.

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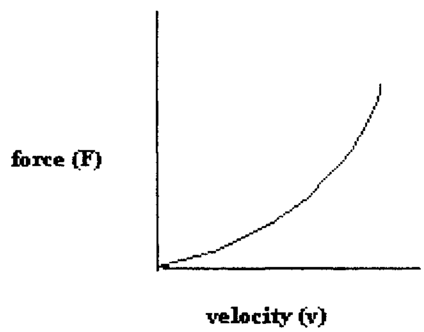
From the equation $F_c = mv^2/r$, it is noted that the mathematical relationship between F and v is one of direct proportion. The curve shown on the right, a parabola, satisfies this relationship. ....**2 points**.............

...............**1 point**



8. A force acting on an object of mass 20. kg changes its velocity from $10\frac{m}{s}$ to $20.\frac{m}{s}$. Determine the change in momentum. **(3 points)**

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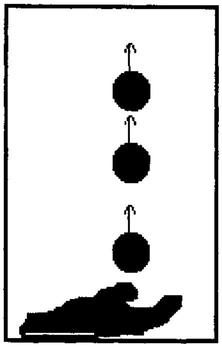
$m\Delta v = mv_f - mv_i =$ ....**1 point**

$20.\ kg(20.\frac{m}{s}) - 20.\ kg(10\frac{m}{s}) =$

$400\ kg\frac{m}{s} - 200\ kg\frac{m}{s} =$ ....**1 point**

$20 \times 10^2\ kg\frac{m}{s}$ ....**1 point**

9.



A ball is thrown vertically upward. As the ball moves upward, do the following quantities, related to the ball, increase, decrease or remain the same: force of gravity, potential energy, kinetic energy? Explain. **(3 points)**

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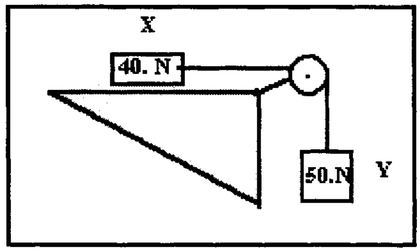
The force of gravity remains constant. "g" is considered constant assuming 'h' is small. **1point**

The potential energy (mgh) increases because 'h', the reference distance, is increasing.............. ....**1 point**

The kinetic energy decreases because the speed decreases on the way up ....**1 point**

10.



A 40.-N weight, X, and a 50.-N weight, Y, are joined together by a light cord that passes over a pulley. Y is released and allowed to fall 0.50 m. What is the change of the system's potential energy, in joules? **(3 points)**

Only the 50-N weight is involved in the solution................. **1 point**
PE = mgh = 50 N x 0.5 m .... **1 point**
= 25 J loss.. **1 point**

1.

Solution

a. $v_2 = v_1 + at$
$v_2 = 60.0\,\frac{m}{s} + (-9.80\,\frac{m}{s^2})(2.00\ s)$
$v_2 = 60.0\,\frac{m}{s} - 19.6\,\frac{m}{s}$
$= 40.4\,\frac{m}{s}$ upward .... **2 marks**

b. $d = v_1 t + 1/2\ at^2$
$d = (60.0\,\frac{m}{s})(2.00\ s) + 1/2(-9.80\,\frac{m}{s^2})(2.00\ s)^2$
$d = 120.\ m - 19.6\ m = 100.\ m$ .... **2 marks**

c. v_2 is zero at maximum height.
$v_2 = v_1 + at$ and $t = v_1/a$; $t = (-60.0\,\frac{m}{s})/(-9.80\,\frac{m}{s^2}) = 6.12\ s$ (When? - after 6.12 s)
.... **2 marks**

d. Either when $v_2 = 0$ or at time 6.12 s. We'll use the time.

$d = v_1 t + 1/2\ at^2 = (60.0\,\frac{m}{s})(6.12\ s) + 1/2(-9.80\,\frac{m}{s^2})(6.12\ s)^2$
$= (367\ m) - 184\ m) = 183\ m$ .... **2 marks**

2.

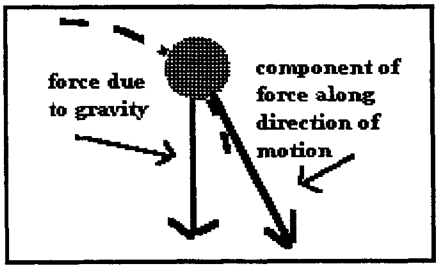
a. Acceleration decreases because the net force on the body decreases. Net force is equal to the student's weight minus the air resistance, and since air resistance increases with increasing speed, net force and hence acceleration decreases. By Newton's second law:

$$a = \frac{F_{net}}{m} = \frac{mg - R}{m}$$

where mg is the weight, and R is the air resistance. As R increases, 'a' decreases. ... **3 marks**

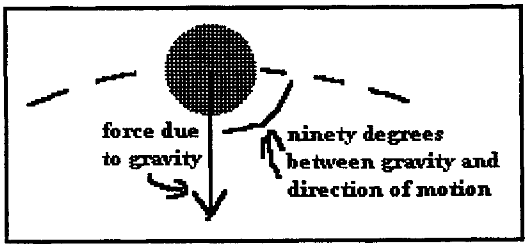
b. Note that if the student falls fast enough so that mg = R, then with no acceleration the student falls at a constant velocity. ....**2 marks**

c. The first cannonball moves downward, so there is a component of gravitational force along its direction of motion that speeds it up.



.... **2 marks**

The second cannonball moves perpendicular to the gravitational force, with no component along its direction of motion. That's why it orbits at constant speed.



.... **1 mark**

3. A 1500-kg car travelling at $12\frac{m}{s}$ crashes into a wall and is stopped in 0.10 s.

   a. Find the average collision force stopping the car during that time. **(4 points)**
   b. How far did the car travel during the collision time? **(4 points)**

Solution

a. $Ft = m(v_2 - v_1)$ .... **1 mark**
   $F = m(v_2 - v_1)/t$ .... **1 mark**
   $F = (1500\ kg)(-12\frac{m}{s})/0.10\ s$ ..... **1 mark**
   $F = -180\ 000\ N$ .... **1 mark**

b. The rate of deceleration is $(-12\frac{m}{s})/0.10\ s = -120\frac{m}{s^2}$ .... **1 mark**
   Starting from 12 m/s and deceleration at $-120\frac{m}{s^2}$, the distance travelled is obtained from $(v_2)^2 = (v_1)^2 + 2ad$, where $v_2 = 0$. .... **1 mark**
   $d = -(v_1)^2/2a = -(12\frac{m}{s})^2/2 \times (-120\frac{m}{s^2}) = 0.6\ m$ .... **2 marks**

Helmet Safety - Sample Response

The head contains a most important and vital organ, the brain. Anything that we can do to protect it, in the pursuit of activities that have the potential of damaging it, is worth the effort. While the brain is encased in a fairly solid container for protection, this container is not impervious to damage by splitting and crushing to cause direct or indirect trauma to the brain. For the little inconvenience that they cause, helmets can make accidents less harmful.

When a bicycle accident occurs, and there is a fall that has the head as the leading part of the body striking the ground, the dynamic forces due to the change in momentum, the static forces due to the weight of the whole body following the head and adding extra force upon impact, and the collision forces inside the head as the movable brain tissue continue to move forward against the inner wall of the skull initially and upon rebound, can cause lethal injuries. Testing limits the crash effect to 300 g's. This means that the head must not undergo a deceleration rate greater than 300 x 9.80 m/s^2, or 2940 m/s^2. This may appear to be excessive, but such decelerations are not unusual in collisions. The formula for acceleration is equal to the change in velocity divided by the change in time,

$$a = \Delta v / \Delta t$$

If the time approached zero, the acceleration would increase dramatically. In such helmet collisions, the time of impact is usually very small. Consequently, the acceleration is very high.

While the skull can absorb some of the resulting force, it will shatter and splinter causing sharp edges to penetrate the brain. Also, because bodies tend to stay in motion due to inertia, the loosely held internal organ as a whole, and its constituent parts, will strike the inner wall of the skull with the same force due to the deceleration effects. This soft tissue will tend to bruise and collapse more easily than the skull under such forces.

While the best solution in preventing serious injuries is to educate bicycle riders as to the inherent dangers, and teach preventive measures, accidents will still happen. Obviously there is some controversy as to whether the present design of helmets can do the job. Design of new materials seems to be essential to reduce the effects of the forces of collision. Materials that give more easily (extend the time and, therefore, reduce the force - impulse = $F\,\Delta t$), and yet distribute the force away from the skull are needed. As can be seen by the expression for impulse, assuming impulse to remain constant as the time is increased, the force is necessarily diminished. For any particular collision, the change in the momentum, which is equal to the impulse (impulse = $m \cdot \Delta v$), is constant.

But will bikers wear helmets with such designs? For example, a helmet that distributes the forces away from the skull to the shoulders may be a solution. This spreads the force over a larger area, and since pressure = F/A, increasing the area over which the force acts diminishes the pressure on any one area of the head. But this would require extensions that the rider may not be willing to wear. While the present helmet does distribute the forces, and therefore reduces the pressure on any one point, the helmet material is not so hard as to prevent localization of an injury because of crushing or distortion, with the consequent increase in pressure on any one point. Increasing the padding thickness, and using harder materials as the skin of the helmet, may give a helmet that protects, but it may be unmarketable.

If you are personally involved, or are close to someone who is injured, a single brain injury is sufficient to make sure protection is used for the head in riding a bicycle. This is particularly true when children are involved. The burden of such injuries for the victim, and those close to him or her, are enormous. The costs to society can add up in terms of short-term and long-term disabilities, and even death. Rehabilitation, loss of normal education avenues, immobility, restricted intellectual development and retention are only some of the effects that head injuries can generate.