APEF

June 2000

Physics 12

MARKING GUIDE

NOVA SCOTIA
Department of Education

APEF PHYSICS EXAM
SELECTED RESPONSE SOLUTIONS
JUNE 2000

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

1. a Distinguish between average speed and instantaneous speed. Use examples to illustrate your answer, if necessary. ... **1 point**
   b. How does constant speed differ from uniform acceleration? How are they the same?.. **2 points**

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Solution

a. Average speed is measured over an incremental time interval, whereas instantaneous speed is measured over a time interval at the limit as 't' approaches zero (or an infinitessimal time interval.) For example, you can find the average speed dividing the distance travelled by the total time. Instantaneous speed is the speed measured on the speedometer of a car at any instant in time. ....**1 mark**

b. The constant in constant speed refers to the same distance per unit time, whereas the uniform in uniform acceleration refers to a constant change in the velocity per unit time. They are the same in that they both imply an unchanging aspect. For the speed it means a constant increase in distance with time, and for acceleration it means a constant change of velocity.
....**2 marks**

2. A car starts from rest and accelerates uniformly. It travels 80. m in the first 10. s. Calculate its final speed at the end of 10. s. .... **3 points**

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Solution

$v_i = 0$

$d = \frac{v_1 + v_2}{2}(t)$

$v_2 = \frac{2d}{t} - v_1$ .... **1 point**

$v_2 = \frac{2(80.\ m)}{10.\ s} - 0$ ... **1 point**

$v_2 = 16\frac{m}{s}$ ... **1 point**

3. A student, on a train leaving the station at time zero, runs down the aisle at 5.0 $\frac{m}{s}$. The train is moving in the same direction as the student at a constant 30. $\frac{m}{s}$. What is the distance between the student and the station after 10. s? ..... **3 points**

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Solution

The resultant velocity of the student is 5.0 $\frac{m}{s}$ + 30. $\frac{m}{s}$ = 35 $\frac{m}{s}$(This is in the direction of the motion of the train.................... **2 points**
In 10. s the distance is 350 m.....**1 point**

4. In a clothing store, a child walks towards a full length mirror with a speed of $2.0\frac{m}{s}$. Relative to the child, what is the velocity of the reflected image of the child? Explain. ... **3 points**

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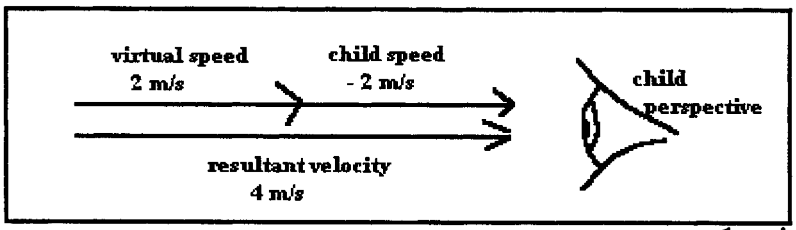
Solution

$4\ \frac{m}{s}$ towards the child. The reflected image has its own virtual speed of $2\frac{m}{s}$, .. **1 point**
while the child approaches the mirror at $2\ \frac{m}{s}$, in the opposite direction. ....**1 point**

The vector solution is as follows:



.... **1 point for correct answer**

(The diagram is not essential to the solution.)

5. It is said that a bus driver could keep the passengers *glued* to their seats by driving at a fast enough constant speed in a straight line. Do you agree? Explain. .... **3 points**

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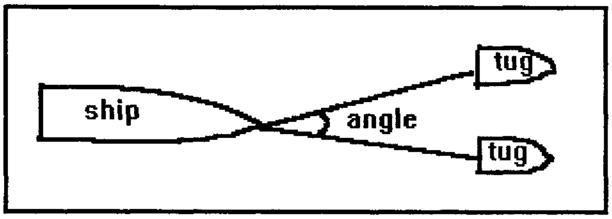
Solution

This could not occur if the bus were travelling at a constant speed. It could only occur during acceleration. .... **1 point**

The passenger in the bus would also be travelling at a constant speed, and due to inertial properties under that condition, the movement of the person would be no different that a person at rest. There would be no tendency for the persons body to be left behind during the motion of the bus, and consequently cause the person to be 'glued' to the seat. ...... **2 points**

6.



Two tugboats assist a ship to dock in a harbour by a rope tied to each tugboat and the ship. What change in the angle between the ropes causes the rate of forward motion of the ship to increase? Explain. .... **3 points**

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Solution

A decrease in the angle between the ropes, assuming no change in the force by the tugs, will give a greater resultant force on the ship... **1.5 points**

This will increase the acceleration, and consequently the rate of change of speed... **1.5 points**

7. Two carts of equal mass collide. One is at rest initially. Show that $\frac{m_2}{m_1} = \frac{v_1}{(v_2)'}$ is correct if the collision is perfectly elastic and the motion is along a straight line path. ... **3 points**

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Solution

In such a collision, $m_1 v_1 + m_2 v_2 = m_1(v_1)' + m_2(v_2)'$ .... **1 point**

Before collision $m_2 v_2$ is zero; after collision $m_1(v_1)'$ is zero.

$m_1 v_1 + 0 = 0 + m_2(v_2)'$ .... **1 point**

$\frac{m_2}{m_1} = \frac{v_1}{(v_2)'}$ .... **1 point**

8. A polar bear, wearing a bulletproof vest, is lying on a horizontal sheet of ice. A hunter fires a bullet at him. The bullet bounces back at almost the same speed, causing the bear to glide down the ice. What difference would it make if the bullet had become embedded in the bear's vest? Explain. ... **3 points**

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Solution

If the bullet has embedded, and assuming a small mass for the bullet, the momentum change would be less than if the bullet bounced off. Therefore, the speed of the bear in the embedded example will be less (a little less than half), because the mass of the bear doesn't change when the momentum is transferred in the non-embedded example.. **1 point**
Assuming no loss, if the bullet bounces back the bear takes on twice the momentum of the bullet ($-2mv_{bullet}$). .... **1 point**
If the bullet embeds, the final momentum of the bear will be $(m_{bear} + m_{bullet})v_{final}$, which is equal to the momentum of the bullet before the collision..**1 point**

9. Is the following statement true or false? Give the physics reasoning that supports your answer.

"If I swing a bucket in a vertical circle over my head, I do not get wet because there is a force pushing the water into the bucket." ..... **3 points**

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Solution

This statement is false.. **1 point**
The water stays in the bucket because it is in motion and tends to travel in a straight line tangential to the circle of rotation. However, the bucket keeps intervening, or keeps getting in the way of the intended path of the water because the bucket is spinning about at the same time.... ....**2 points**

(However, the water could cause a force on the bottom of the bucket at the top, depending on the speed. If the speed is great enough to cause a centripetal force greater than the weight of the object, there will be a force exerted on the bottom of the bucket. However, this is not the force keeping the water in the bucket, but the 'third law pair' force between the tension on the bucket, through the hand-string extension, and the water.)

10. Why are road accidents at very high speeds very much worse than at very low speeds? Justify your answers by refering to the magnitude of the changes of energy and energy transformation as the speeds get higher. ... **3 points**

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Solution

The transfer of energy in a collision is essentially determined by $KE = \frac{1}{2}mv^2$ . ...**1 point**

So the energy transfer is directly proportional to the square of the speed of the vehicles. At greater speeds, the difference in the energy values get increasingly greater and greater. For example, if you double the speed, the energy input goes up by four times, and if you triple the speed, the energy input goes up by nine times. Since the energy input into a collision generally determines the severity of the accident, accidents at higher speeds are increasingly much worse than at low speeds. .... **2 points**

1.

Solution

a. In lifting the stone and allowing it to drop, the stone exerted a force equal to its weight(static force), but also exerted a dynamic force = ma,.. **2 points**
which is great enough, when added to the weight of the stones, to break the string... .... **1 point**

b.
There could have been gradual deceleration, $(v_f - v_i)/t$, and hence a diminution of the force acting at any one time on the string................................. .... **2 points**

c. When pulled slowly horizontally, there was time for the stones to accelerate without stretching the string beyond the breaking points. However, when pulled with a jerk, the inertia of the stone caused the stone to accelerate at a slower rate than the string parts. Consequently, the string parts separated (broke) before the stones could gain sufficient acceleration............. **3 points**

2.

Solution

a. First calculate the vertical and horizontal components of velocity .

Vertical = ($1386\ \frac{m}{s}$ x Sin 37.0^o) Horizontal = ($1386\frac{m}{s}$ x Cos 37.0^o)

vertical - $834\frac{m}{s}$ and horizontal - $1110\frac{m}{s}$ .... **2 points**

$t = v/a = (834\ \frac{m}{s})/(9.80\frac{m}{s^2}) = 85.1$ s up or down. Total time = 170. s .... **2.5 points**

b. Range = v_h x t = $1110\ \frac{m}{s}$ x 170. s = 189 000 m .... **2 points**

c. In a direction parallel to the ground - $1110\frac{m}{s}$ .... **0.5 points**

Vertically - $834\frac{m}{s}$ .... **0.5 points**

Along the trajectory, assuming hitting at 37.0^o.

$(v_{trajectory})^2 = (834\ \frac{m}{s})^2 + (1110\ \frac{m}{s})^2$

$v_{trajectory} = 1390\ \frac{m}{s}$ .... **0.5 points**

3.

Solution

a. The law of conservation of momentum yields the following solution for the speed.

$v_{after} = m(v_{initial})/2m = (1.00\text{ kg})(0.500\frac{m}{s})/(2 \times 1.00\text{ kg}) = 0.250\frac{m}{s}$ .... **2 points**

b. kinetic energy before = kinetic energy of the moving cart = $1/2mv^2$

$= 1/2(1.00\text{ kg})(0.500\frac{m}{s})^2$

$= 0/125$ J .... **2 points**

Kinetic energy after = $1/2(2m)v^2 = (1/2)(2 \times 1.00\text{ kg})(0.250\frac{m}{s})^2 = 0.0625$ J .. **2 points**

c. Work is done in compressing the plasticine - which raises the temperature as a result .. **1 point**

d. The heat energy produced must be added. .... **1 point**

Sample Response - Surface

The data related to injuries in sports specifically targets those under fifteen years of age. In these years the youth is still developing and growing. The cost and number of injuries to all age categories must be staggering. The social trauma and social costs totally must be huge by comparison to that given in the question. It certainly deserves a detailed analysis for the sake of those injured, and society at large.

The vertical component of the force gives information for considering the cushioning effect. In order to achieve a cushioning effect, the length of time that the force acts on the foot, or any other part of the body, must be increased. Otherwise, the deformation of the surface due to the foot impinging on it must be increased. This can be discerned in the data tables.

The first table (surface deformation) shows that for softer surfaces the deformation is greater, extending the distance over which the force acts - an energy formulation.
The energy formulation is Fd = change in the energy. As the distance increases during collision the force reduces - an inverse relationship. Note the difference between the deformation for astroturf versus concrete, for example. The deformation for astroturf is about eleven times as great, reducing the force on the body dramatically.

Likewise the second table (interaction time) indicates that for softer surfaces the time of impact is increased. According to the impulse formulation, Ft = change in momentum, the force is greatly reduced for extremes of surfaces - say concrete vs astroturf. The ratio is about 3.3 to 1.

This reduction in force comes about because there is a certain change in momentum involved when the body, say the foot, strikes the ground. This change in momentum is independent of the surface on which the person is playing. However, the force of interaction varies. The momentum change is caused by the reactive impulse of the ground on the body, as noted above. If the time over which the force acts is lengthened, the average force will decrease because the product of the two is constant and equal to the momentum change.

From the energy point of view, in order for the surface to reduce the kinetic energy of the colliding body to zero, it must exert an upward force. The product of that force times the distance of deformation of the surface is equal to the kinetic energy brought into the system. In order to reduce the average force, the surface deformation distance must be increased.

It would seem that the solution to the costs of injuries and the trauma suffered by children under fifteen, in particular, is either to take special care as to the surfaces on which the sport is played, or provide all participants with appropriate cushioning protection on their body, like well-cushioned footwear. Two activities stand out for a quick solution; others are less quickly solved.

Dancing, particularly ballet practice, is usually done on hard, minimally deforming surfaces. Schools of dance should be required to install surfaces for dance that deform in a way that reduces the stress on young feet. Another is volleyball. There is no reason that volleyball players have to play on hard surfaces like hardwood, gym floors. Unlike basketball, once the ball strikes the floor, the point is lost anyway. Beach volleyball is a good example for a surface that reduces injuries. The soft sand extends the time of deformation upon contact, reducing the injuries on this surface. I am not suggesting that we spread sand on gym floors, but the game could be played on a covering that provides more cushioning to the feet, ankles and other body parts. A hard floor is not necessary to successfully play the sport.

I think that those in charge of sporting activity, from the government to athletic clubs, have an obligation to protect young athletes from many kinds of injury, or body deformation, by providing appropriate surface protection in the form of deformable surfaces. The extra cost of the technology would be offset, in the long run, by the savings in medical costs at emergency centres at hospitals.