Student Name: ________________________ Positive Education Group: _________

AOS3: How Fast Can Things Go
SAMPLE SAC

Reading Time: 5 minutes
Writing time: 45 minutes
QUESTION AND ANSWER BOOK

Structure of book

Number of questions	*Number of questions to be answered*	*Number of Marks*
8	**8**	**45**

Students are permitted to bring into the test room: pens, pencils, highlighters, erasers, sharpeners, rulers, a scientific calculator, one double sided A4 sheet of notes

- Students are NOT permitted to bring into the test: electronic devices, blank sheets of paper, notes of any type and/or white out liquid/tape.

Materials supplied

- Question and answer book. Formula sheet

Instructions

- Write your **name** in the space provided above on this page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorized electronic devices into the test room.

Question 1 (2+2+2+2+2=10 marks)

A student riding on the Pharaoh's Curse ride at Luna Park drops a calculator from their pocket when they are 9 metres above the ground. The calculator has a mass of 0.13 kg. The calculator leaves their pocket with an initial horizontal velocity of 2 m/s.

a. How long does the calculator take to hit the ground?

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____

s

b. What is the vertical component of the velocity as the calculator hits the ground?

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m/s

c. What is the total speed of the calculator as it hits the ground?

m/s

d. How far away in the horizontal direction does the calculator land from the point at which it was dropped?

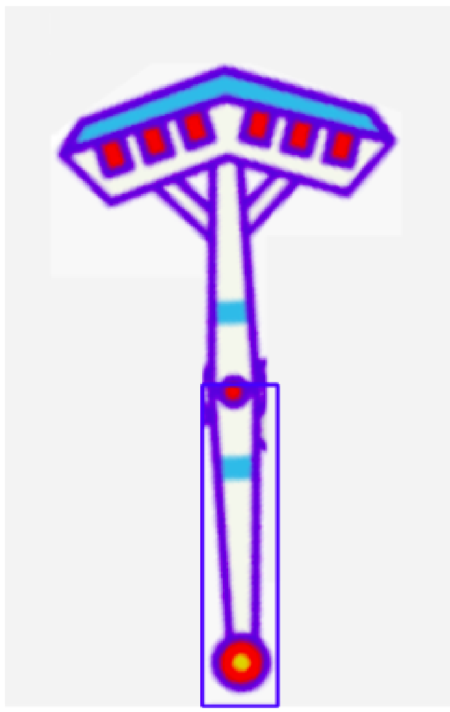
m

e. How would the values of horizontal distance travelled change if air resistance was taken into account?

Question 2 (3+3=6 marks)

Students analyse the forces in the Pharoh's Curse ride. Once the ride reaches full speed, each carriage completes a full vertical circular rotation. A diagram of one of the arms is shown below. The radius of the arm is 9 m. The carriage is travelling at 6 m/s at the top of the rotation.

a. Draw an arrow to indicate each of the following forces on the rider:
   Net force
   Force due to gravity
   Normal force



b. Determine the magnitude of the normal force on a 70 kg rider at the top of the rotation

N

Question 3 (1 +2 = 3 marks)
Students are riding on the Coney Island drop.

The carriage rises 10 metres above the ground before freefalling for 5 metres.

a. Describe the energy conversions in the ride

b. Calculate the velocity of a student after the 5-metre freefall if the initial velocity is 0 m/s

m/s

Question 4 (2+3+2+2=9 marks)

Students ride the dodgem cars. Each car has a total mass of 250 kg, including the masses of the students. Car A is travelling at 5 m/s to the right and collides with the back of Car B, which is stationary. Car B moves to the right at 3 m/s after the collision

a. Calculate the momentum of the Car A prior to the collision

m/s

b. Determine the speed and direction of Car A after the collision

Speed

m/s

Direction (circle)

Left/Right

c. Is this an elastic or inelastic collision? Justify your answer.

d. Explain why Luna Park bans head-on collisions on the dodgem cars, referencing key physics principles

Question 5 (2 marks)
Students examine the Spider Ride and note that the connection between the arm of the Spider and the carriage can be approximated by a right-angled triangle. See the diagram below.

Calculate the tension in the arm of the spider approximated by the hypotenuse of the triangle given the horizontal side length of the triangle is 2.5 m and the angle the arm makes with the vertical is 30 degrees. The mass of the empty carriage at the end of the arm is 40 kg.

N

Question 6 (2 marks)

A number of rides are closed due to the wet weather. Explain why rain decreases the safety of certain rides, referencing key physics principles

Question 7 (3+ 2+2 =7marks)

Students are sheltering from the rain and begin discussing Einstein's Theory of Relativity.

a. Explain the differences between Einstein's Theory of and classical mechanics, making references to key physics principles

b. Students debate when the relativistic effects become observable. Determine the velocity a body would be travelling if it had a Lorentz factor of 1.10

m/s

c. Students imagine a rocket is passing Earth with a velocity of 0.92c. People on Earth measure the rocket to be 15.5m in length. Calculate the length of the rocket as measured by the astronauts onboard the rocket.

m

Question 8 (3+ 3 = 6 marks)

You have been asked to create a new ride for Luna Park. The ride has to have the following features:

- ❏ Participants must feel lighter than usual at one point in the ride
- ❏ Participants must feel heavier than usual at one point in the ride

a. Describe how you would design the ride with the above specifications and justify your design by referencing key physics principles. You may include diagrams and/or sample calculations in your response

b. Describe what safety features you will include in your ride and outline how these will protect the rider from injury, referencing key physics principles. You may include diagrams and/or sample calculations in your response

End of Assessment

Formula Sheet: Can be detached

Motion and related energy transformations

velocity; acceleration	$v = \frac{\Delta s}{\Delta t}$; $a = \frac{\Delta v}{\Delta t}$
equations for constant acceleration	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $s = vt - \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(v + u)t$
Newton's second law	$\Sigma F = ma$
circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
Hooke's law	$F = -k\Delta x$
elastic potential energy	$\frac{1}{2}k(\Delta x)^2$
gravitational potential energy near the surface of Earth	$mg\Delta h$
kinetic energy	$\frac{1}{2}mv^2$
Newton's law of universal gravitation	$F = G\frac{M_1 M_2}{r^2}$
gravitational field	$g = G\frac{M}{r^2}$
impulse	$F\Delta t$
momentum	$m\Delta v$
Lorentz factor	$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$
time dilation	$t = t_o \gamma$
length contraction	$L = \frac{L_o}{\gamma}$
rest energy	$E_{rest} = mc^2$
relativistic total energy	$E_{total} = \gamma mc^2$
relativistic kinetic energy	$E_K = (\gamma - 1)mc^2$

Data

acceleration due to gravity at Earth's surface	$g = 9.8$ m s^{-2}
mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
charge on the electron	$e = -1.6 \times 10^{-19}$ C
Planck's constant	$h = 6.63 \times 10^{-34}$ J s $\quad h = 4.14 \times 10^{-15}$ eV s
speed of light in a vacuum	$c = 3.0 \times 10^{8}$ m s^{-1}
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
radius of Earth	$R_E = 6.37 \times 10^{6}$ m

Prefixes/Units

p = pico = 10^{-12}	n = nano = 10^{-9}	μ = micro = 10^{-6}	m = milli = 10^{-3}
k = kilo = 10^{3}	M = mega = 10^{6}	G = giga = 10^{9}	t = tonne = 10^{3} kg