PHYSICS COURSEWORK
ASTEROIDS

Asteroids, also known as small or minor planets are irregular bodies that vary in size and composition. They are usually found in the inner solar system among planets and primarily move in indirect orbits between the orbits of Jupiter and Mars, however some orbit relatively nearby to Earth. This is the prime concern with asteroids; where in the past collision with Earth has had tremendous affects and possibility of future collisions will always exist. This concern has been popularised in many forms and everyday the rate of technology intended to reduce the impact of any likely future asteroid collision is expanding. In order to demonstrate an increase or decrease in the impact of an asteroid, measurable by its crater size, my outcome variable is: How a chosen factor affects the diameter of an impact crater.

There are many factors that have a form of influence to the affect of an asteroid collision:

Mass – The gravitational potential energy stored by an object is significantly determined by the amount of matter an object contains. As the mass of an object increases, the potential increases, hence the kinetic energy increases causing an increase in the size of impact.

Speed **–** The speed the asteroid is travelling at will have a major affect on the impact of the crater. Crater size increases with increasing speed.

Height – The speed of the asteroid is dependant on the height at which it is falling. Therefore these two variables are linked.

Air resistance – Small objects / balls have very little air resistance. This can be easily demonstrated because it takes a long time for a ball to slow down so only a small amount of energy is lost when the ball is dropped. Large objects are affected by a significant amount of air resistance, this will change the way the object moves.

Gravity – Objects are moved by the force of gravity pulling on it. Gravity on earth would enhance the attractiveness of an asteroid, whereas on the moon, where the pull of gravity is less, the object would take more time to collide with the surface.

Directed medium – The composition of the medium in which the asteroid collides will have an affect on the resulting crater size. The same asteroid would have a different result colliding with two contrary mediums, dependant on the content and varying moisture.

Angel of impact – From the craters that have been observed in the past, it has been established that those with a collision at a specific oblique angle were amongst the largest. Therefore the angel of collision has an influence.

Each of the above mentioned factors do have a form of influence to an asteroid collision, however not all can be recreated in accordance to my experiment. Therefore I will rule out each factor that is irrelevant or shows a sign of possible obstruction when it comes to doing the actual experiment.

The first exclusion is the angel of impact. This is primarily due to the reason that it would be too difficult to setup and furthermore beyond measure. The second is

evenly between air resistance and gravity. This is logically due to the reason that amongst the apparatus I am provided with to conduct the experiment, these factors will be immeasurable. And last is speed as this isn't actually an input variable, more of an output variable to the height at which the projectile is falling. Therefore speed is irrelevant and it wouldn't be possible to set the values of speed prior to the experiment. Therefore this leaves me with mass, height and the directed medium all of which can be altered in order to demonstrate an influence.

These 4 factors will all have a form of involvement, however I will primarily only concentrate on one, thus my aim:

AIM: To investigate how mass affects the diameter of an impact crater.

Therefore mass is the independent variable. As an independent variable, it simply means I will need to change the mass throughout the experiment in order to demonstrate a possible influence.

I have chosen mass because I believe this will have a powerful relevance to the shape, size and depth of a crater and also I believe it will be interesting to observe how varying masses affect the diameter of a crater. Also as this is set as an independent variable, I will have independent control over the values I pre-set it to prior to experimentation.

The dependant variable is the variable dependant on others to produce a result and also what I am trying to find out about. Therefore the dependent variable is the actual diameter of impact crater.

And the height and directed medium are set as the control variables. These will need to be kept constant throughout the experiment in order to ensure a fair test as any unexpected alterations during the experiment may affect the accuracy of my results.

BACKGROUND KNOWLEDGE:

For a collision to occur, the colliding object would need to contain energy. Energy is the ability of an object to cause change. In strict scientific terms energy is classified into two main forms: potential and kinetic energy.

Potential energy is energy stored in matter which appears in many different forms, and is defined as the energy in matter due to its position or the arrangement of its parts. The various forms of potential energy include gravitational potential energy.

When something is lifted or suspended in air, work is done on the object against the pull of gravity. This work is converted to a form of potential energy called gravitational potential energy. The gravitational potential energy of an object depends on its mass and the height at which it is falling. This can be demonstrated using the following formula of gravitational potential energy:

$U = mgh$ **u= gravitational potential energy, m = mass, g = gravitational constant, and h = height**

The formula shows that the gravitational potential energy is directly proportional to both the mass and the height of an object. This shows that the heavier an object is,

the more gravitational potential energy it has, and the higher an object is, the more gravitational potential energy it has.

However gravitational potential energy is not the outcome that causes the shock wave. When the object succumbs to the force of gravity, falling towards Earth, it converts all its potential energy into kinetic energy where most of this kinetic energy is transferred to the medium, creating a shock wave, and the rest converted into waste energy which may consist of sound, heat and light. The shock wave will cause the sand to move. This proves that kinetic energy, also known as motion energy, is the outcome energy that actually creates the impact.

Therefore the kinetic energy depends on how much mass an object contains and the height at which it is falling. This can be demonstrated through the formula of kinetic energy:

$$\boxed{K = 1/2\ mv^2}$$ **k = kinetic energy, m = mass, and v = speed**

The formula shows that kinetic energy is directly proportional to the square of the speed and to the mass. Which in return proves that the more mass an object contains, the more energy it has, meaning the amount of matter an object contains determines the impact of collision.

An example of this would be catching a dropped ball from a building. You would rather wish to catch a tennis ball than a bowling ball, because since the bowling ball is heavier than the tennis ball, it has more stored energy which would result in a larger collision. This determines my prediction:

PREDICTION: Crater diameter increases with increasing mass.

As well as justification of my prediction through background knowledge, below is an optical demonstration:

PRELIMINARY WORK:

In order to ensure a fair test is carried out and the best possible variables are used in order to conduct an accurate experiment, I will need to carry out preliminary work. This will consist of: experimentation of height, directed surface, and mass.

To produce reliable results I will need to ensure that only one of the variables is changed at a time and each recording is repeated twice. From this I should be able to calculate an average which will help me in choosing a reasonable criterion for each variable.

Height and directed surface will need to be experimented in order to determine the most advantageous constant height at which the projectile will be dropped from and optimal directed surface where the ball will land. This is to ensure these variables compliment and help produce accurate results when varying masses. For example if I unreliably choose to use a constant height of 30cm without any preliminary work, a problem may arise during the experiment where there isn't a major difference between the different recordings for the varying masses, which wouldn't produce results as intended.

The independent variable, mass, also needs to be covered in my preliminary work to determine the best range of values I will set it to for the actual experiment. Also this will make it easier for me and save time later as I would already be familiar with the composition of the balls.

Preliminary work will also allow me to identity any arising problems at an early stage and determine the required apparatus needed to complete the experiment.

Preliminary results:

Varying height

HEIGHT (CM)	DIRECTED SURFACE	MASS (G)	CRATER SIZE (MM)			
			1	2	3	Mean
20	Fine aquarium gravel	Golf ball (42)	65	64	63	64
40	Fine aquarium gravel	Golf ball (42)	86	86	87	86.33
60	Fine aquarium gravel	Golf ball (42)	93	93	92	92.66

The table shows that as the height at which the ball is dropped from increases the crater size also increases. However from the preliminary work I have decided that I will keep a constant height larger than the ones tested. This is so more disperse results will be produced which will make the results clearer in order to notice any trends.

Varying directed surface

DIRECTED SURFACE	HEIGHT (CM)	MASS (G)	CRATER SIZE (MM)			
			1	2	3	Mean
Fine aquarium gravel	50	Golf ball (42)	91	91	92	91.33
Silver sand	50	Golf ball (42)	93	94	93	93.33
Fine sand	50	Golf ball (42)	94	94	94	94

As can be seen from the table, there is not much difference between the crater sizes produced when the golf ball is dropped into different directed surfaces. However if my intervals of height were higher then more disperse results would most likely be produced.

Varying mass

MASS (G)	HEIGHT (CM)	DIRECTED SURFACE	CRATER SIZE (MM)			
			1	2	3	Mean
Ping pong (2.6)	50	Fine aquarium gravel	42	42	40	41.33
Plasticine (29.1)	50	Fine aquarium gravel	64	62	63	63
Golf ball (42)	50	Fine aquarium gravel	92	93	92	92.33

As can be seen from the table, mass has a significant affect on the crater size.

Amongst the balls I was to experiment during my preliminary was a steel ball, however initial testing showed that the ball sunk right into the directed surface which

would have made it difficult to measure accurately. So I replaced it with plasticine, and I discovered that the size of the plasticine could be altered in order to vary the mass. So I was able to alter the size to match a similar mass of a steel ball.

The usefulness and findings of my preliminary results, in accordance to the actual experiment, can be found in the variable table below:

Dependent Variable	**value**	**how measured**
Crater size	Centimetre (cm) Recording should be repeated twice	Vernier caliper
Independent Variable		
Mass	Grams (g) 5-35	Electric scale
Control Variables		
Height	Centimetre (cm) 100 constant	Metre ruler
Directed surface	Fine aquarium gravel constant	

As mentioned earlier, using plasticine I am able to alter the mass to a range required. This is primarily the reason why I have chosen to use plasticine constantly throughout the experiment. By means of altering the mass for each recording I will be able to pre-set the intervals by 5g as required. Whereas if I were to use different balls I wouldn't be able to present a range of results through varying ranges.

METHOD:

I am now able to verify the apparatus needed to complete the investigation:

- Large plastic tray
- Fine aquarium gravel to fill the tray
- Plasticine
- Meter ruler to measure height
- Two stand, bosses & clamps to hold metre ruler and plasticine ball
- Standard ruler used for leveling of aquarium gravel
- Electric scale to measure mass of plasticine
- Vernier caliper to measure crater size
- Safety goggles (optional)
- Set square (optional)

Below is a diagram showing how the apparatus should be set up:

The following steps will need to be carried out in order to conduct an accurate and more importantly successful experiment:

1. Begin by setting out the apparatus as shown in the diagram above. It is required that 1/3 of the plastic tray is filled with the provided fine aquarium gravel.

2. Ensure that the boss of the clamp is positioned directly above the surface so an attached ball will fall directly below onto the surface.

3. Knowing the first range of mass is 5g, using the plasticine adjust the size until the mass totals 5g on the electric scale.

4. Tighten the plasticine ball to the boss of the clamp ensuring that it is positioned at 50cm height. A set square can be used to ensure the ball is placed at a straight angle.

5. Using the standard ruler provided smooth the fine aquarium gravel so it is level.

6. Now ensuring that the plasticine is positioned at the correct height (50cm), it is placed at a straight angle and the surface is smooth, loosen the boss and the plasticine should fall onto the surface using the force of only gravity.

7. Without putting any pressure on the ball, remove it from the surface.

8. Finally using a vernier caliper measure the diameter of the created crater. The results of this should be recorded into the results table.

9. In order to produce the most accurate results possible, repeat stages 3-8 twice more using the same mass of plasticine. However it is required the mass of plasticine is measured again as this may have changed during the first recording.

10. Repeat the whole experiment again but stage 3 should be altered so the mass of plasticine is 5g heavier than the one before. This procedure should continue until you have recorded final results for 35g.

Safety is not a major factor to take into consideration. However it is optional to wear safety goggles in order to avoid a rare occasion of any fine aquarium gravel coming into contact with eyes. And as usual general safety will need to be carried out by placing bags away from the area used for the experiment and ensure the desk is cleared of all books and stationary.

RESULTS:

PLASTICINE MASS (G)	HEIGHT (CM)	DIRECTED SURFACE	CRATER SIZE (MM)			
			1	2	3	MEAN
5	100	Fine aquarium gravel	31	32	31	31.33
10	100	Fine aquarium gravel	35	36	35	35.33
15	100	Fine aquarium gravel	39	38	40	38
20	100	Fine aquarium gravel	44	46	45	45
25	100	Fine aquarium gravel	51	50	52	51
30	100	Fine aquarium gravel	53	57	61	57
35	100	Fine aquarium gravel	55	67	63	61.66

I found that altering the size of the plasticine to match the required range was time consuming and at times recordings had to be repeated as the mass wasn't accurate. However using plasticine gave me additional independent control than I would have had if I used a range of different balls.