Exponential Models 1

The equation for the exponential decay of a population is $N(t) = N_0 e^{-\lambda t}$. N_0 is the initial population, λ is a constant and t represents time.

Using the following data, describing the depletion of an animal population,

Time (days)	Animal population
1	66626
2	44384
3	29575
4	19705
5	13128
6	8747
7	5828

find the values of N_0 and λ.

N_0 | λ

Give your answer to 1 significant figure.

Give your answer to 1 significant figure.

Exponential Models 4

The relationship between two variables, x and y, is $y = y_0 e^{-x/b}$. Below is a plot of y against x.

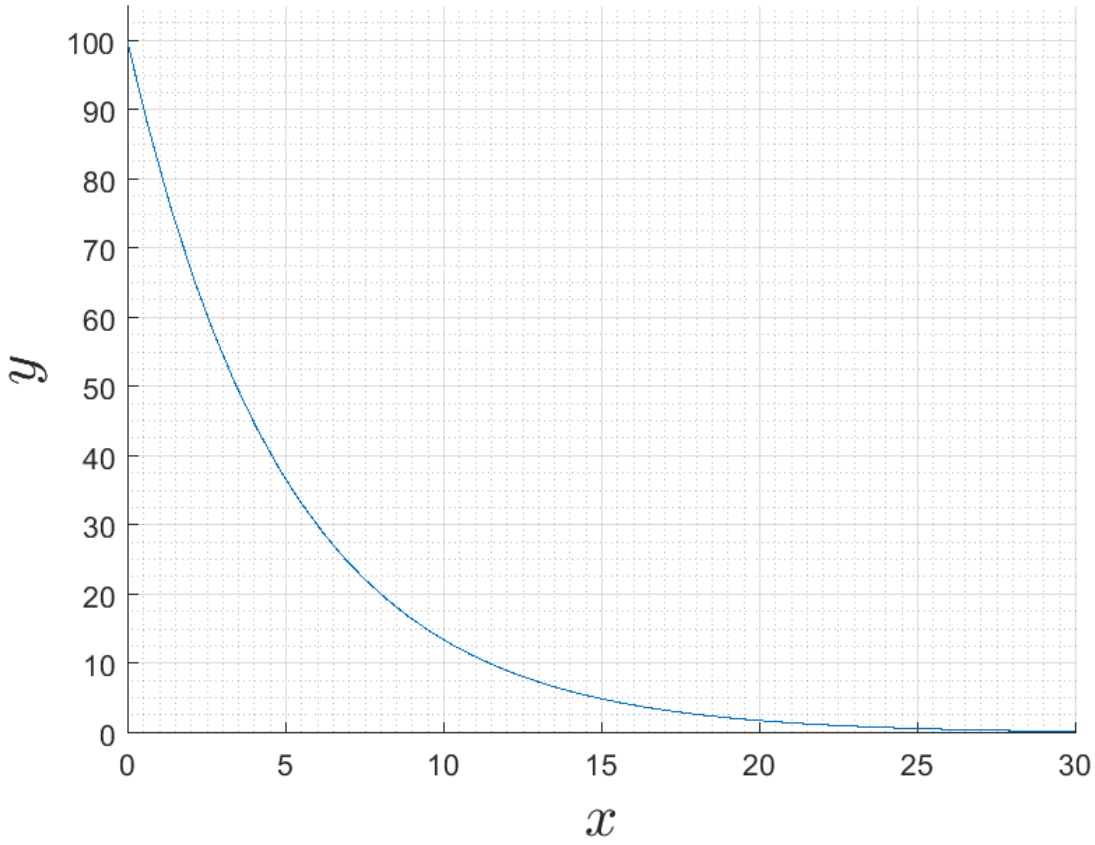

Figure 1: Plot of $y = y_0 e^{-x/b}$.

Use this graph to find y_0 and b.

y_0	b

Give your answer to 1 significant figure.

Toppling Block

A Level

This problem involves friction, which is not covered in some Physics A Levels. For more information please check with your teacher.

A rectangular block with a square base of side $10\,\mathrm{cm}$ rests on a rough horizontal surface. A slowly increasing horizontal force is applied to one vertical face. If this force is applied near the bottom of the face then as the force increases the block will slide before it topples. If the force is applied near the top then the block topples over before it starts to slide. When the force is applied $20\,\mathrm{cm}$ from the bottom, the block sometimes slides and sometimes topples.

Find the coefficient of friction between the block and the surface (to 2 significant figures).

Essential Pre-Uni Physics A6.2

GCSE C C C A Level P P P

The table below shows the formula for a particular physical relationship, and what has been plotted on the x and y axes. You should write down (in terms of the letters in the formula) what the y-intercept and gradient will be. If the graph is not going to be a straight line, write 'not straight' instead of a gradient.

Equation	Plotted on y	Plotted on x	y-intercept	Gradient
$s = \frac{1}{2}gt^2$	s	t^2	(a)	(b)

Part A y-intercept

What is the y-intercept?

- 0
- $\frac{\sqrt{g}}{2}$
- g
- $\frac{g}{2}$
- $\frac{1}{2}$

Part B Gradient

What is the gradient?

- $\frac{1}{2}$
- $\frac{g}{2}$
- $\sqrt{g}$
- g
- Not straight

Essential Pre-Uni Physics A6.4

GCSE C C C A Level P P P

The table below shows the formula for a particular physical relationship, and what has been plotted on the x and y axes. You should write down (in terms of the letters in the formula) what the y-intercept and gradient will be. If the graph is not going to be a straight line, write 'not straight' instead of a gradient.

Equation	Plotted on y	Plotted on x	y-intercept	Gradient
$\frac{L}{T} = \lambda f + D$	T^{-1}	λ	(a)	(b)

Part A y-intercept

What is the y-intercept?

- $\frac{D}{L}$
- f
- 0
- D
- $\frac{f}{L}$

Part B Gradient

What is the gradient?

- Not straight
- f
- fL
- $\frac{D}{L}$
- $\frac{f}{L}$

Essential Pre-Uni Physics A6.5

GCSE C C C A Level P P P

The table below shows the formula for a particular physical relationship, and what has been plotted on the x and y axes. You should write down (in terms of the letters in the formula) what the y-intercept and gradient will be. If the graph is not going to be a straight line, write 'not straight' instead of a gradient.

Equation	Plotted on y	Plotted on x	y-intercept	Gradient
$\frac{1}{R} = \frac{1}{S} + \frac{1}{T}$	R^{-1}	S^{-1}	(a)	(b)

Part A y-intercept

What is the y-intercept?

- T
- $\frac{1}{T}$
- 0
- $\frac{R}{T}$
- Undefined

Part B Gradient

What is the gradient?

- 0
- 1
- $\frac{1}{T}$
- T
- Not straight

Essential Pre-Uni Physics A6.7

GCSE C C C A Level P P P

The table below shows the formula for a particular physical relationship, and what has been plotted on the x and y axes. You should write down (in terms of the letters in the formula) what the y-intercept and gradient will be. If the graph is not going to be a straight line, write 'not straight' instead of a gradient.

Equation	Plotted on y	Plotted on x	y-intercept	Gradient
$d \sin\theta = n\,\lambda$	$\sin\theta$	n	(a)	(b)

Part A y-intercept

What is the y-intercept?

- d
- 1
- λ
- 0
- Undefined

Part B Gradient

What is the gradient?

- d
- λ
- Not straight
- $\frac{\lambda}{d}$
- 0

Gravitational Field of a Planet

A Level

The gravitational field strength (g) at various distances (r) from the centre of a small planet is given in the table.

$r/10^6\,\mathrm{m}$	$g/\mathrm{N\ kg^{-1}}$
0.24	0.402
0.48	0.804
0.72	1.21
1.20	2.01
1.68	1.03
2.16	0.621
2.64	0.416
3.12	0.298

The gravitational field strength is proportional to the distance to an unknown power $(g \propto r^n)$. Plot an appropriate graph to determine the power(s).

Part A Power n when distance is small

What is the power n in the power law $g \propto r^n$ when the distances from the planet's centre are small?

Part B Power n when distance is large

What is the power n in the power law $g \propto r^n$ when the distances from the planet's centre are large?

Created for isaacphysics.org by Anton Machacek.

Leaning Ladder

A Level

This problem involves friction, which is not covered in some Physics A Levels. For more information please check with your teacher.

A uniform ladder of mass m and length l leans against a frictionless wall at an angle θ to the horizontal, with its bottom resting on a rough surface with a coefficient of friction μ .

If $\theta = 30\,^\circ$, what is the minimum value of μ such that the ladder does not slip?

- $\mu = \frac{1}{2\sqrt{3}}$
- $\mu = 1$
- $\mu = \frac{\sqrt{3}}{2}$
- $\mu = \frac{1}{2}$
- The ladder will not slip, no matter what the value of μ is.

Created for isaacphysics.org by Michael Conterio.

What to Plot?

A Level

To make sense of data, we need to plot an appropriate graph. Often we want a graph which would be a straight line if our model were correct. In these questions, choose what to plot on the axes to give a straight line if the data fits the suggested equation.

Part A Violin tension

A musician measure the frequency (f) of sounds made by a violin as they change the tension (T) in one of its strings. A physicist suggests that the frequency is proportional to the square root of the tension.

The musician prepares a graph with T on the x-axis. Which quantity should they plot on the y-axis?

- f
- f^2
- $\sqrt{f}$
- $1/f$

Part B Focusing with a lens

A student is experimenting with a mobile data projector. They focus it on screens at different distances (v) from the lens. Each time, they also measure the distance (u) between the lens and the LCD 'object' inside the projector. A website tells them that for thin lenses $\frac{1}{u}+\frac{1}{v}=P$ where P is a constant for each lens.

What should they plot to see if the lens in the projector is behaving like the lens on the website?

- Plot $\frac{1}{v}$ against u
- Plot v against $\frac{1}{u}$
- Plot v against u
- Plot $\frac{1}{v}$ against $\frac{1}{u}$

Once they have plotted the correct graph, if the website is right, they will get a straight line. What is the gradient of this straight line?

- -1
- P
- $-P$
- 1
- P^{-1}

Once they have plotted the correct graph, if the website is right, they will get a straight line. What is the y-intercept of this straight line?

- $-P$
- P^{-1}
- 1
- -1
- P

Part C Polarizer

A student is measuring the intensity of light (I) which passes through a pair of polarizers whose axes make an angle A to each other. A textbook suggests that the intensity is given by $I = I_0 \cos^2 A$ where I_0 is a constant. They wish to plot I on the y-axis of their graph in a way which will give a straight line if the data fit the textbook formula. What should they plot on the x-axis?

The following symbols may be useful: `A, I, I_0, cos()`

Part D Radioisotope

A student measures the activity (A) of a short-lived radioactive source in a classroom. They want to use a straight line graph to help them work out the decay constant (λ). The student knows that, once background corrections have been made, the activity will follow the relationship $A = A_0 e^{-\lambda t}$ where t is the time since the start of the experiment and A_0 is a constant.

To get a straight line, what should they plot?

- Plot A against t
- Plot A against $\ln t$
- Plot $\ln A$ against t
- Plot $\ln A$ against $\ln t$

Once they have chosen the correct variables to plot, what will the y-intercept be?

The following symbols may be useful: `A_0, lambda, ln(), t`

Once they have chosen the correct variables to plot, what will the gradient be?

The following symbols may be useful: `A_0, lambda, ln(), t`

Part E Compressed gas

When a gas is compressed sufficiently rapidly that it can't exchange heat with its surroundings, the value of pV^γ is constant where p is the pressure, V is the volume and γ is constant. At room temperature, for a monoatomic gas (like helium) $\gamma = \frac{5}{3}$ whereas for a diatomic gas like nitrogen $\gamma = \frac{7}{5}$.

A student investigates the compression of a gas, measuring p and V in order to determine γ and find out if the gas is monoatomic. What should they plot to get a straight line graph from which they can work out γ?

- Plot $\ln p$ against $\ln V$
- Plot p against V
- Plot p against $\ln V$
- Plot $\ln p$ against V

Once they have plotted an appropriate graph

- the y intercept will be $\ln \gamma$
- the gradient will be $-\gamma$
- the gradient will be $\frac{1}{\gamma}$
- the gradient will be $\ln \gamma$
- the y intercept will be γ
- the gradient will be γ