isaac You work it out.

STEM SMART Physics 35 - Using Series

Pascal's Resistors

Subject & topics: Physics | Electricity | Resistors **Stage & difficulty:** A Level C3

The diagram below shows an infinite array of resistors. Each resistor in the array has a resistance of the reciprocal of the number for pascals triangle for that position.

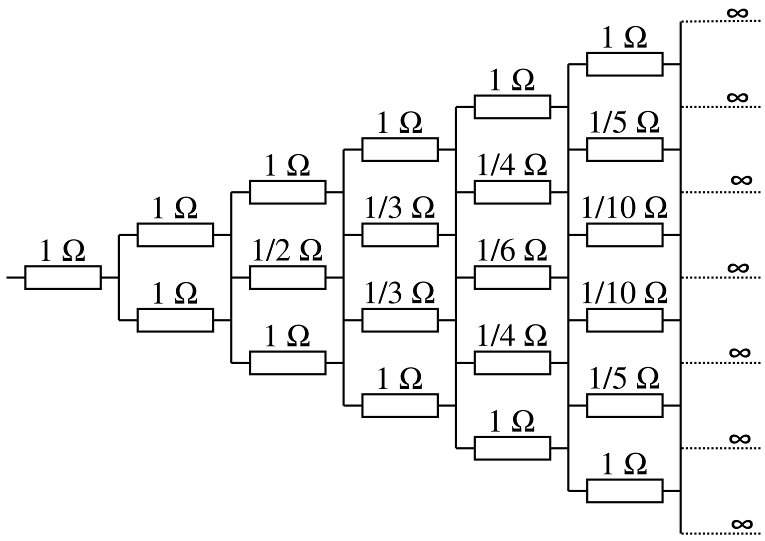

Figure 1: Circuit diagram showing an infinite array of resistors.

Find the equivalent resistance of the array, for a current flowing through the $1\,\Omega$ resistor at the left hand end through to the right hand end. Answer to 3 significant figures.

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Geometric Series 4

Pre-Uni Maths for Sciences C2.10

Subject & topics: Maths | Algebra | Series **Stage & difficulty:** A Level C2

A bouncing ball loses the same fraction of its energy every time it bounces i.e. when dropped from an initial height h, after its first bounce it rises to a height αh, after the second bounce $\alpha^2 h$ and so on (α is a number less than 1). Find an expression for the total distance travelled.

The following symbols may be useful: `alpha, h`

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Integrating Powers 4

Pre-Uni Maths for Sciences K2.10

Subject & topics: Maths | Calculus | Integration **Stage & difficulty:** A Level C2, Further A P2

Part A

Integrate $\frac{A}{r^7} - \frac{B}{r^{13}}$

Find $\displaystyle\int_a^\infty \left(\frac{A}{r^7} - \frac{B}{r^{13}}\right) \mathrm{d}r$.

(The force between, for example, two atoms of an inert gas, a distance r apart is given by $\left(\frac{A}{r^7} - \frac{B}{r^{13}}\right)$, where A and B are (negative) constants; the first term is the attractive force between them (the van der Waals interaction, due to their fluctuating induced dipoles) and the second is the repulsive force due to the overlap of their electron shells. The integral describes the potential energy of such a system i.e. the work done bringing one atom from infinity to within a distance a of the other atom.)

The following symbols may be useful: `A, B, a`

Part B

Integrate $\frac{C}{x^2} + D$

Find $\displaystyle\int_{x_1}^{x_2} \left(\frac{C}{x^2} + D\right) \mathrm{d}x$.

(The function $\left(\frac{C}{x^2} + D\right)$, where C and D are constants, could describe the component of an electric field in the x-direction due to a combination of the field due to a point charge at the origin and a uniform field in the x-direction. The integral is then the potential difference between two points x_1 and x_2 on the x-axis.)

The following symbols may be useful: `C, D, x_1, x_2`

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Apparent Magnitudes

Pre-Uni Maths for Sciences E3.9

Subject & topics: Maths | Functions | General Functions **Stage & difficulty:** A Level C2

The apparent magnitude m of an astronomical object describes on a logarithmic scale how bright an object appears to an observer. It is related to its actual brightness or energy flux F (i.e. the energy arriving at the Earth per unit area per second) in the following way. Consider two objects with magnitudes m_1 and m_2 and brightnesses F_1 and F_2; the relationship between these quantities is

$$\frac{F_1}{F_2} = 100^{\frac{m_2 - m_1}{5}} .$$

Part A

Sun and Moon

The magnitude of the Sun is -26.8 and it is a factor of 4.80×10^5 brighter than the full Moon. Find the magnitude of the full Moon.

Part B

Supernova 1987A

Supernova 1987A was discovered in the nearby dwarf galaxy the Large Magellanic Cloud and, with a magnitude of $+2.9$, it was visible with the naked eye. It was subsequently discovered that its progenitor was a blue supergiant with a magnitude of $+12.2$. Find the ratio of the brightness of Supernova 1987A to that of its progenitor (give your answer to 2 sig figs).

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Energy Decay

Pre-Uni Maths for Sciences E3.10

Subject & topics: Maths | Functions | General Functions **Stage & difficulty:** A Level C2

A steel bar is tapped on one end and the resulting pulse of energy travels backwards and forwards along the bar. A very small fraction α of its energy is lost on each reflection so that after n reflections the fraction of its initial energy left is $(1-\alpha)^n$. It takes a time τ to travel from one end of the bar to the other.

Part A

Time for energy to halve

Find an expression for the time it takes for the energy in the pulse to halve.

Use either $\log_{10}$, or the natural log, $\ln$. When you are entering your answer, note that $\log_{10} a$ can be written using `log(a,10)`.

The following symbols may be useful: `alpha`, `ln()`, `log()`, `tau`

Part B

Time for energy to fall by factor of 100

Find an expression for the time it takes for the energy in the pulse to fall by a factor of 100.

Use either $\log_{10}$, or the natural log, $\ln$. When you are entering your answer, note that $\log_{10} a$ can be written using `log(a,10)`.

The following symbols may be useful: `alpha`, `ln()`, `log()`, `tau`

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Exponential Extrapolation 7

Essential Pre-Uni Physics K2.7

Subject & topics: Physics | Waves & Particles | Optics **Stage & difficulty:** A Level P3

It is advisable to have completed section J3 before beginning the questions in section K2.

It is said to be safe to view the Sun through a filter if it only lets 10^{-5} of the light through. Suppose you have some material which lets 2.0% of the light through. How many sheets do you need to put together back-to-back before you can safely look through it at the Sun? NB - Never make your own filter for viewing the Sun in this way - most filters bleach with very high intensities and aren't designed with eye protection in mind, so the quality is not good enough for a device which is to prevent blindness. Give your answer to 1 significant figure.

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Exponential Extrapolation 9

Essential Pre-Uni Physics K2.9

Subject & topics: Physics | Waves & Particles | Nuclear **Stage & difficulty:** A Level P3

It is advisable to have completed section J3 before beginning the questions in section K2.

The thickness of lead needed to stop half of the neutrinos in a beam is about $3000\,\mathrm{lightyears}$ (which you may take as $3.0 \times 10^{19}\,\mathrm{m}$).

Calculate the fraction of neutrinos which would be stopped by $100\,\mathrm{m}$ of water assuming that the attenuation coefficients for water and lead are about the same (which they're not). You may need to use the approximation $\mathrm{e}^x \approx 1 + x$ provided x has a small magnitude.

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Exponential Extrapolation 10

Essential Pre-Uni Physics K2.10

Subject & topics: Physics | Skills | Relationships **Stage & difficulty:** A Level P3

It is advisable to have completed section J3 before beginning the questions in section K2.

You start with a credit card debt of £150. For each month in which you don't pay it off, the debt increases by 3.0%. Assuming you pay nothing for $3.0\,\mathrm{years}$, and then want to settle the debt in one go, how much would you have to pay in pounds? Give your answer to 3 significant figures.