Pop-up Toy

A Level

C C C

A pop-up toy consists of a head and sucker of combined mass m stuck to the top of a light spring of natural length l_0 and spring constant k. The spring is compressed to length l_1 when the pop-up is stuck to the ground.

To what height above the ground does the bottom of the unstretched spring jump to when it is smoothly released?

The following symbols may be useful: `g, k, l_0, l_1, m`

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Melting a Snowman

GCSE C C C A Level C C C

Two red LEDs are the eyes of an evil snowman, with a circuit inside its head. This question will allow you to work out how long it takes for the snowman to melt.

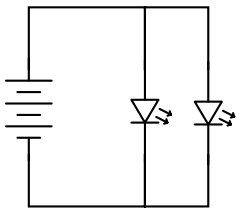

Figure 1: The circuit diagram for the snowman's eyes.

Part A Total power

The voltage across the battery is $6.0\,\mathrm{V}$ and the current drawn from the cell is $0.23\,\mathrm{A}$.

What is the total power produced by both LEDs?

Part B Mass of ice

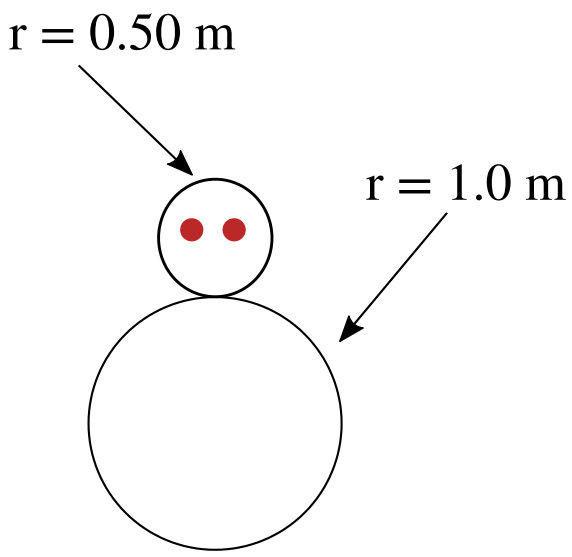

Figure 2: The snowman. The head and body are spherical with radii of $0.50\,\mathrm{m}$ and $1.0\,\mathrm{m}$ respectively.

The ice has a density of $930\,\mathrm{kg\,m^{-3}}$.

Work out the mass of ice in the snowman.

Part C Time taken to melt

The specific latent heat of fusion of ice is $335\,\mathrm{J\,g^{-1}}$. Assume that the snowman is at $0.0\,^{\circ}\mathrm{C}$ and the LEDs are $30\,\%$ efficient at converting electrical energy to light energy, with the remainder being converted to heat energy.

Calculate the time that it takes for all the ice in the snowman to melt due to the LEDs. Assume that the light emitted by the LEDs is not absorbed by the ice, and that all of the heat produced by the LEDs goes to melting the ice. Give your answer in years.

Created for isaacphysics.org by Vandan Parmar, Maria-Andreea Filip and Richard Simon

Gameboard:

STEM SMART Physics 38 - Puzzle week

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Step up to GCSE Challenge Questions 47.8

Year 9 GCSE

A water-ethanol mixture has a density of $0.95\,\mathrm{g/cm^3}$. What percentage of the volume of the mixture is ethanol? For water $\rho_w = 1.00\,\mathrm{g/cm^3}$, for ethanol $\rho_e = 0.79\,\mathrm{g/cm^3}$.

In this question, assume that the total volume doesn't change when water is mixed with ethanol.

Gameboard:

Puzzle Week Draft Board

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Step up to GCSE Challenge Questions 47.2

Year 9 GCSE

A student lives in a room with a gas heater, and her rent includes an allowance of $4.0\,\mathrm{GJ}$ of heating. When $1.0\,\mathrm{m}^3$ of gas is burnt, it releases $40\,\mathrm{MJ}$ of heat. The student's gas meter reads in cubic feet where $1\,\mathrm{ft} = 0.305\,\mathrm{m}$. If the meter reads 653400 when she starts living there, what will it read when she has used up her allowance?
Give your answer as the numbers that appear before the decimal point. **Do not** round.

Gameboard:

Puzzle Week Draft Board

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A Jet in the Fog

A Level

C C C

A person is standing on top of a mountain on a foggy day. The fog obscures their vision beyond a distance $r = 500\,\mathrm{m}$. A fighter jet is travelling in a straight line at constant speed on a horizontal flight path at the same altitude as the person on the mountain (but is not flying directly towards them).

The person uses a stopwatch to measure the time interval between when the jet first becomes visible and when the jet is loudest (sound was emitted when it was closest to them). They then measure the time interval between the loudest noise they hear and the jet exiting their field of vision. Their first measurement is $T_1 = 1.60\,\mathrm{s}$, and their second is $T_2 = 1.00\,\mathrm{s}$.

The speed of sound in air is $340\,\mathrm{m\,s^{-1}}$ and we can assume the time taken for light to travel between the plane and the mountain is negligible.

Part A Distance to closest point

Find the distance, d, to the point of closest approach.

Part B Speed of the jet

Find v, the magnitude of the velocity of the jet.

Created for isaacphysics.org by Jan Zamirski and James Sharkey.

Gameboard:

Puzzle Week Draft Board

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Stop the Train

A Level

C C C

A steam train moving with a speed of $v_0 = 60\,\mathrm{km\,h^{-1}}$ is brought to rest by first shutting off the steam, when the train runs against a resistance equal to $1/100$ of its weight, and later by applying the brakes, at which point the train runs against a force equal to $1/8$ of the weight of the train.

If the steam is shut off when the train is a distance $d = 0.33\,\mathrm{km}$ from a station, find the distance from the station that the brakes must be applied in order that the train may be brought to rest in the station.

Adapted with permission from UCLES, Higher School Certificate Physics, June 1923, Paper 2, Question 1.

Gameboard:

Puzzle Week Draft Board

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A Ballistic Pendulum

A Level

C C C

A block of wood with a mass of $M = 2.5\,\mathrm{kg}$ is suspended from fixed pegs by vertical strings $l = 3.0\,\mathrm{m}$ long, in a set up known as a ballistic pendulum. A bullet with a mass of $m = 10\,\mathrm{g}$ and moving horizontally with a velocity $u = 300\,\mathrm{m\,s^{-1}}$ enters and remains in the block.

Find the maximum angle θ to the vertical through which the block swings.

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Mirage

GCSE C C C A Level C C C

A thin layer of calm air immediately above a hot, flat desert is at the same temperature as the desert ground beneath it. Above this layer the temperature of the air abruptly changes to a uniform cooler value. A person with eyes $h = 2.00\,\mathrm{m}$ above the ground has the impression that they are standing at the centre of a circular 'island' of sand, surrounded by a mirror-like surface, reminiscent of water.

Part A Refractive index of warm air

Calculate the refractive index for the warm air if the horizontal distance from the person to the rim of this 'island' is $L = 20.2\,\mathrm{m}$ and the refractive index of the cooler air is 1.05.

Part B Apparent radius

As the day progresses, the bottom layer of air heats up even more, changing the refractive index to 1.02, what is the new radius of the man's 'island'?

Adapted with permission from UCLES, A Level Physics, June 1967, Paper 2, Question 2

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Measuring Resistances

GCSE C C C A Level P P P

The unknown resistance R of a resistor can be measured by comparing with a $100\,\Omega$ standard. A potentiometer slide-wire, which consists of a bare wire with constant resistivity, so that contact can be made at any point along its length, is used to find two balance points where the current through the ammeter is zero, when A is connected to B or C.

When A is connected to B, the balance point was found to be when $l = 400\,\text{mm}$.

When A is connected to C, the balance point was found to be when $l = 588\,\text{mm}$.

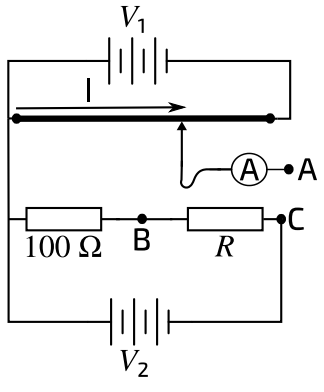

Figure 1: Circuit diagram showing the points A, B and C, the length l, and the resistances of the two resistors.

What is the value of R?

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