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Answers to 2019 O level Physics practical 6091/ Paper 3

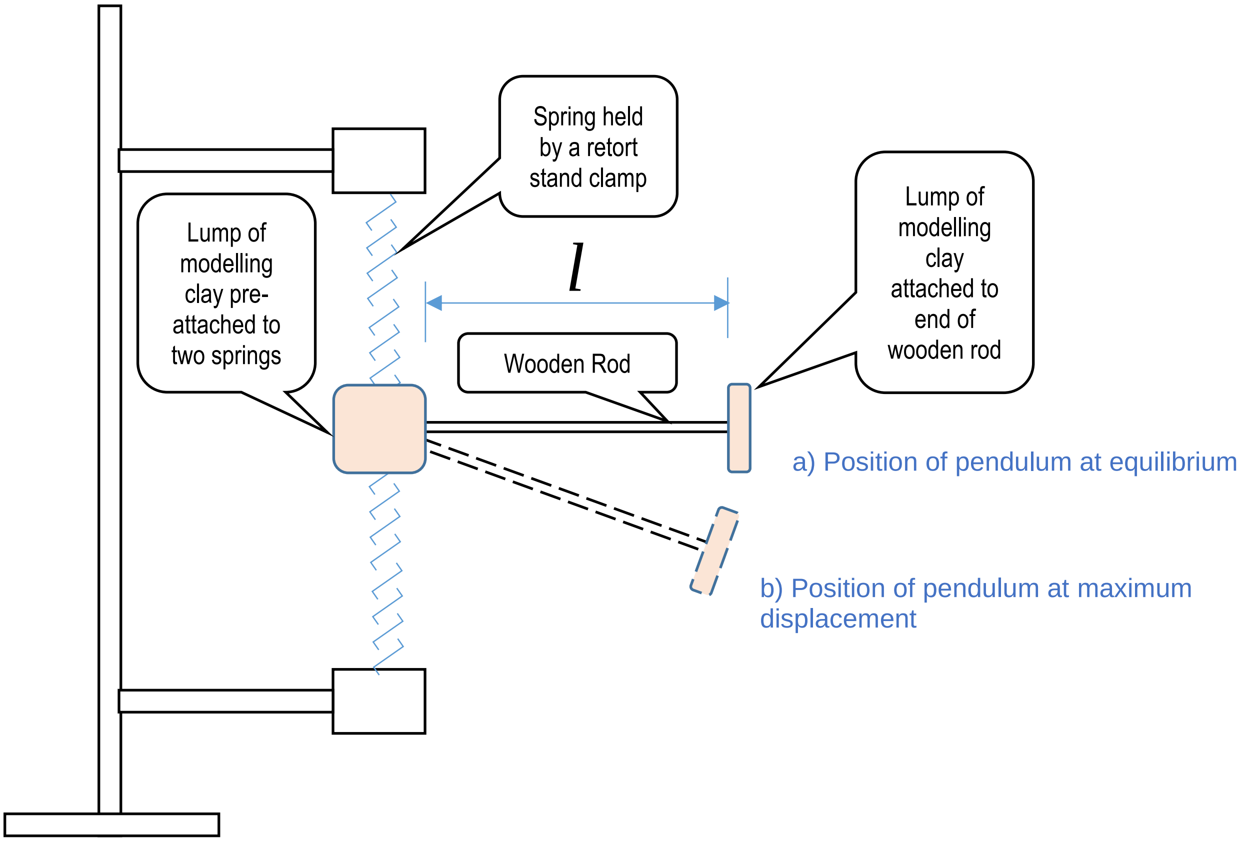
Note! We have received mixed feedback on the accuracy of the questions below from our students.

The 2019 O level Physics practical paper had 3 questions. The first question was based on oscillations, the second on speed/acceleration and the third question was based on a light dependent resistor (LDR).

Question 1

a) Candidates were asked to determine the period & the length of a pendulum. The pendulum was made up of a wooden rod and a lump of modelling clay. Candidates were asked to measure the length, **L** of the pendulum and the period, **T**.

The equation relating **L** and **T** was also given as $T^2 = aL + b$.



Teacher's Note! For small amplitude oscillations, i.e about 10°, the period (T) of oscillation is related to length (L) by the formula $T = 2\pi\sqrt{\frac{L}{g}}$, where g is the acceleration of gravity. Rearranging this formula, we get $T^2 = L\left(\frac{4\pi^2}{g}\right)$. Substituting these values into the above equation, $T^2 = aL + b$, **therefore** $a = \left(\frac{4\pi^2}{g}\right)$.

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b) For the 2nd part of this question, candidates were asked to design another experiment to determine the value of **b**.

Teacher's Note!

a) Use our knowledge on the relationship between the period (T) of oscillation and the length (L) of the pendulum.
b) Record the period of oscillation, T_0 when the lump of modelling clay is attached to END of the wooden rod, where the length (L) of the pendulum is L_0.
c) Move the lump of modelling clay 2cm nearer to the lump of modelling clay pre-attached to two springs. Record the period of oscillation as T_1 and the length (L) of the pendulum as L_1. Please note that $L_1 < L_0$.
d) Keep moving the lump of modelling clay 4cm, 6cm, 8cm, etc. nearer to the lump of modelling clay pre-attached to two springs. Record the period of oscillation as T_2, T_3, etc. and the length (L) of the pendulum as L_2, L_3, etc.
e) Plot a straight-line graph of T^2 against L.
f) Y-intercept of this straight line must be equal to b.

The following section is included based on the feedback received from students that the question asked candidates to rotate the wooden rod (with the lump of modelling clay attached at the end) towards them along the horizontal plane by 90°. Upon releasing the wooden rod, they were asked to measure the period of oscillation about the vertical axis.

Teacher's Note!

a) Rotating the wooden rod (with the lump of modelling clay attached at the end) towards them along the horizontal plane by 90° causes a mechanical deformation of the spring.
b) When released, a restoring torque returns the wooden rod (with the lump of modelling clay attached at the end) to its original vertical axis.
c) Many students reported that upon reaching the vertical axis, the wooden rod (with the lump of modelling clay attached at the end), oscillated about positions a) and b) as shown in the diagram above (on the previous page).

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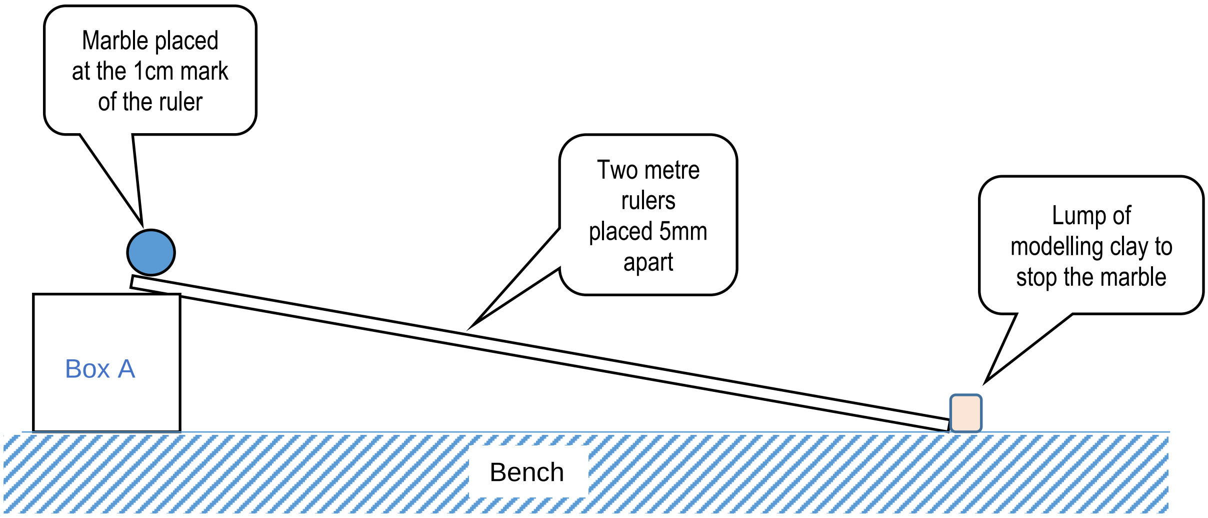
Question 2

a) Candidates were asked to determine the acceleration of a marble rolling down in between two metre rulers placed 5mm apart.

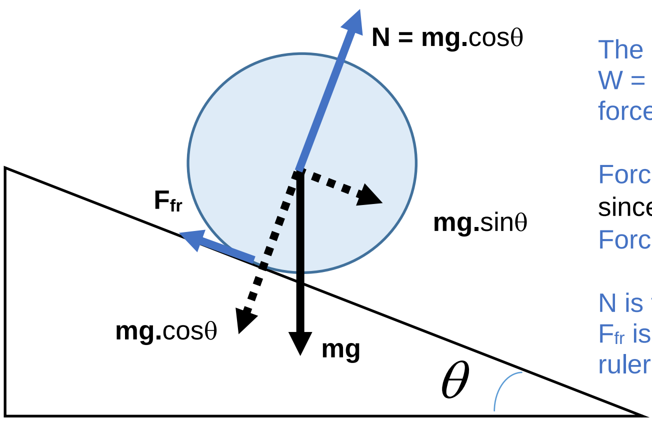


Candidates were asked to measure the time, t_{51}, taken for the marble to roll past the 51cm mark and the 99cm mark, t_{99}. Since the distance travelled is known the speed of the marble rolling past the 51cm mark and the 99cm mark was calculated. i.e. V_{51} and V_{99}.

Using acceleration, $a = \frac{V_{99} - V_{51}}{t_{99} - t_{51}}$, candidates were asked to calculate the acceleration of the marble. They were then asked to compare their practically obtained value of the acceleration with a theoretical value where acceleration, $\boldsymbol{a = g\sin\theta}$, where g is the acceleration of free-fall and is equal to $10ms^{-2}$.

Teacher's Note!

A free-body diagram for a marble rolling down the ruler is shown below.



The downward force is caused by the weight, W. W = mg. Resolving this W into two perpendicular forces, we get:

Force parallel to metre ruler surface = **mg.**sinθ and since F = ma, **ma** = **mg.**sinθ and **a** = **g.**sinθ.
Force perpendicular to metre ruler surface = **mg.**cosθ

N is the normal force and is = **mg.**cosθ
F_{fr} is the frictional force between the marble and the ruler.

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Experimentally obtained value of acceleration will deviate from theoretical value of $gsin\theta$ as

(i) **frictional forces (due to surface of ruler and air resistance) are not constant;**
(ii) **human reaction time error in seeing the marble cross the 51cm/99cm mark and stopping the timer;**
(iii) **similar to a simple suspension bridge, the metre ruler forms a catenary curve due to its own weight (the dead load) and the additional weight of the marble rolling down (the live load) $\Rightarrow$ non-uniform acceleration.**

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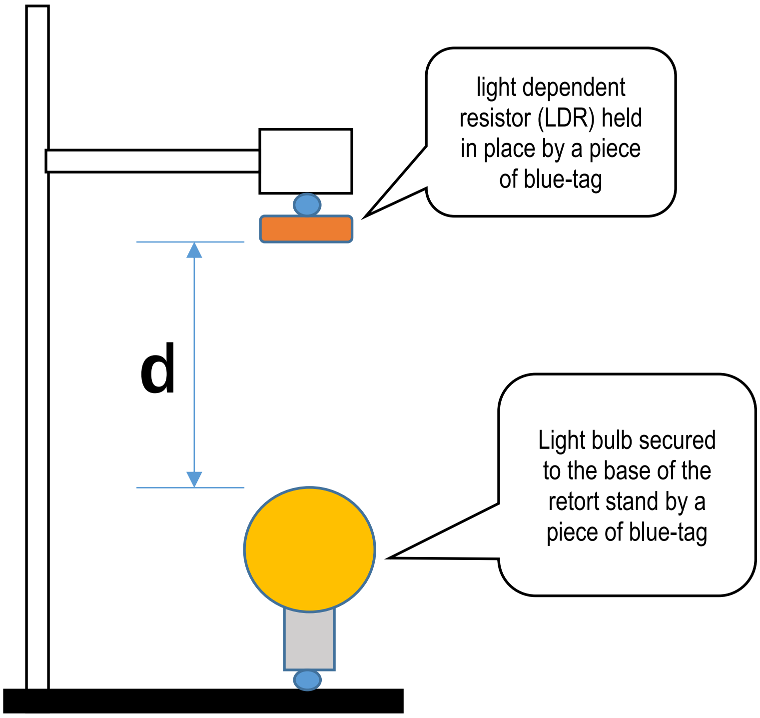
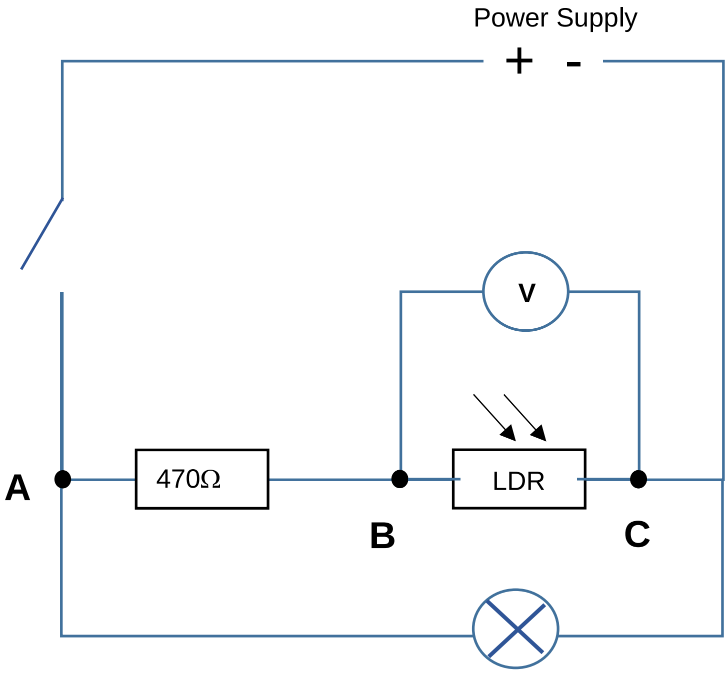
Question 3

a) The third question was about light dependent resistors (LDR) and candidates were asked to determine the relationship between the resistance, **R** of the LDR and the distance, **d** from the light source, which was a bulb.



Position of the light bulb and the LDR could be moved.

The circuit was connected as shown below.



The following formula was used to find the current, **I**, in the circuit.

$$I = \frac{V_{AB}}{R}$$

Where R = 470 Ω.

Knowing the current, **I**, in the circuit, the resistance of the LDR was determined using

$$R_{LDR} = \frac{V_{LDR}}{I}$$

Where $V_{LDR} = V_{Source} - V_{AB}$

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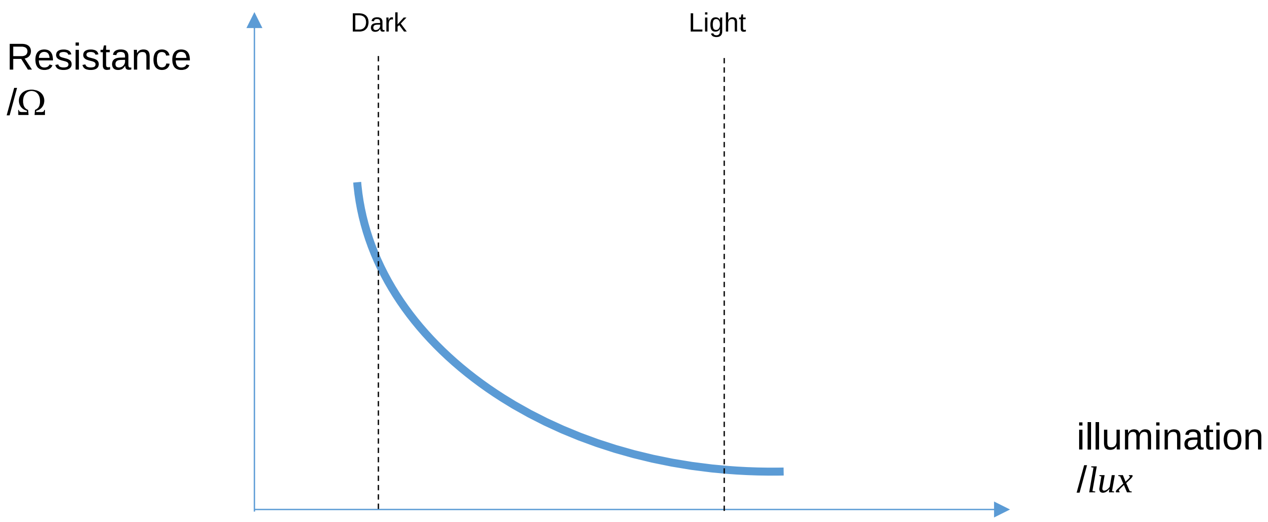
Candidates were then asked to tabulate values of **R_{LDR}** as the distance, **d** was varied between 1.0cm to 4.0cm.

Distance, d/cm	**R_{LDR} / Ω**	**Change in resistance/ Ω**
1.0 cm	**R_{LDR}** @ 1.0cm	Not Applicable
1.5 cm	**R_{LDR}** @ 1.5cm	**Change in R_{LDR}** = **R_{LDR}** @ 1.5cm – **R_{LDR}** @ 1.0cm
2.0 cm		
2.5 cm		
3.0 cm		
3.5 cm		
4.0 cm		

<u>Teacher's Note!</u>

For an LDR, theory tells us that resistance (measured in Ω) and illumination (measured in Lux) are related as:



The above graph shows a hyperbolic relationship between resistance, R and illumination, lux. Therefore, R is proportional to $\frac{1}{(lux)^n}$, where n is dependent on the specifications of the LDR.

For some of the LDRs used in our lab, we found n approximately equal to 0.714 but we are not sure of the specification of LDRs used for O level examinations.

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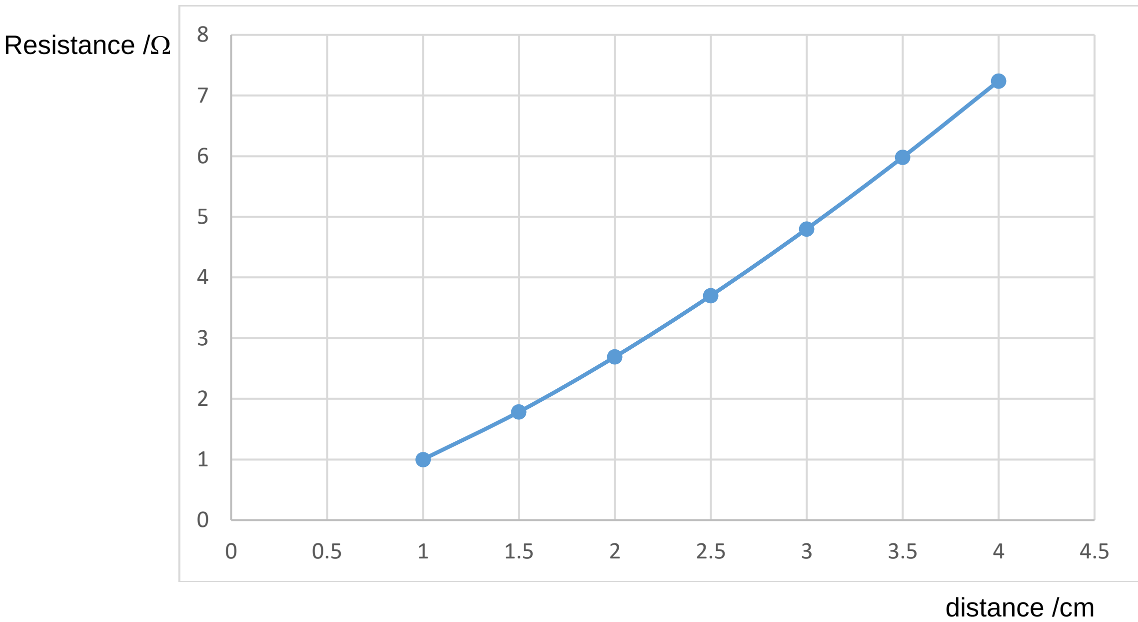
Luminous intensity, which measures brightness of bulb, (measured in candela) is related to distance, d and illumination, lux by:

Luminous intensity = (distance)^2 x illumination

And since the brightness of the bulb was constant,

Illumination (lux) is proportional to $\frac{1}{(distance)^2}$ **,**

As such, a plot of resistance (R) versus distance (d) should've looked something like:



For the LDRs used in our lab, for a distance of between 1.0cm to 4.0cm, the variation in voltage was too small and so a high sensitivity (detects a very small amount of change) voltmeter was required.

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