ProjectAcademy

2021 | PROJECT ACADEMY **EXAMINATION**

X

HSC Physics

Sample responses

General Instructions

- Reading time – 5 minutes
- Working time – 30 minutes
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper

Total marks: 18

Section I – 18 marks

- Attempt Question 1
- Allow about 30 minutes for this section

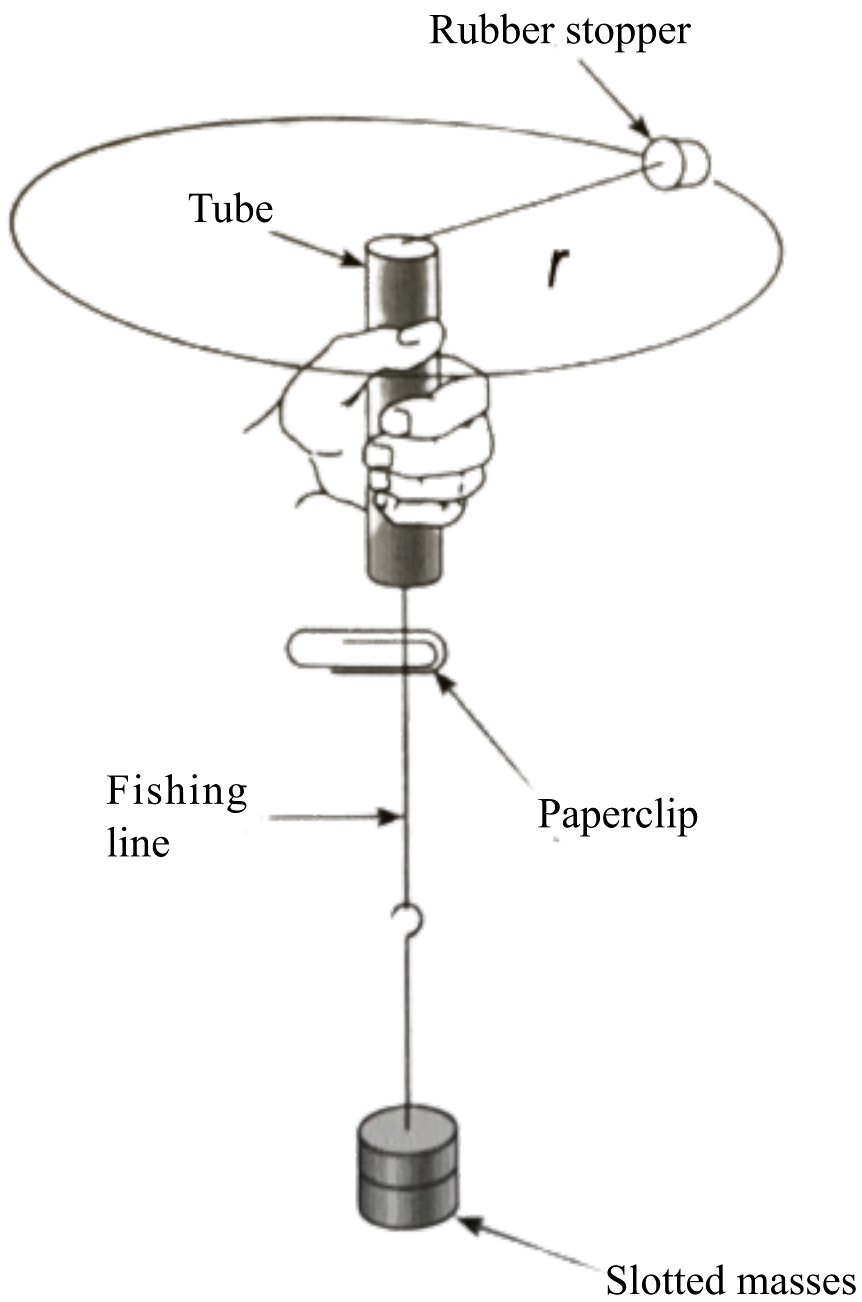
Please note that these are only suggested responses and there may be more answers in some cases.

Question 1 (18 marks)

A group of Physics students designed an experiment to quantify the centripetal force acting on a rubber stopper travelling in uniform circular motion.

The rubber stopper was connected to a brass mass-carrier with a light, inextensible nylon string (fishing line) passing through a polished glass tube to reduce friction.

A diagram is included below:



One of the students started rotating the stopper in a circular path at a radius of 0.8m using the paperclip as a guide. This distance was measured using a metre ruler. The time for five complete revolutions was measured using a stopwatch, to determine the period of rotation.

The mass on the mass-carrier was changed in order to vary the weight force acting downwards. The speed of rotation was then varied to keep the stopper rotating at the same fixed radius of 0.8m for each run.

Question 1 continues on the next page

Question 1 (continued)

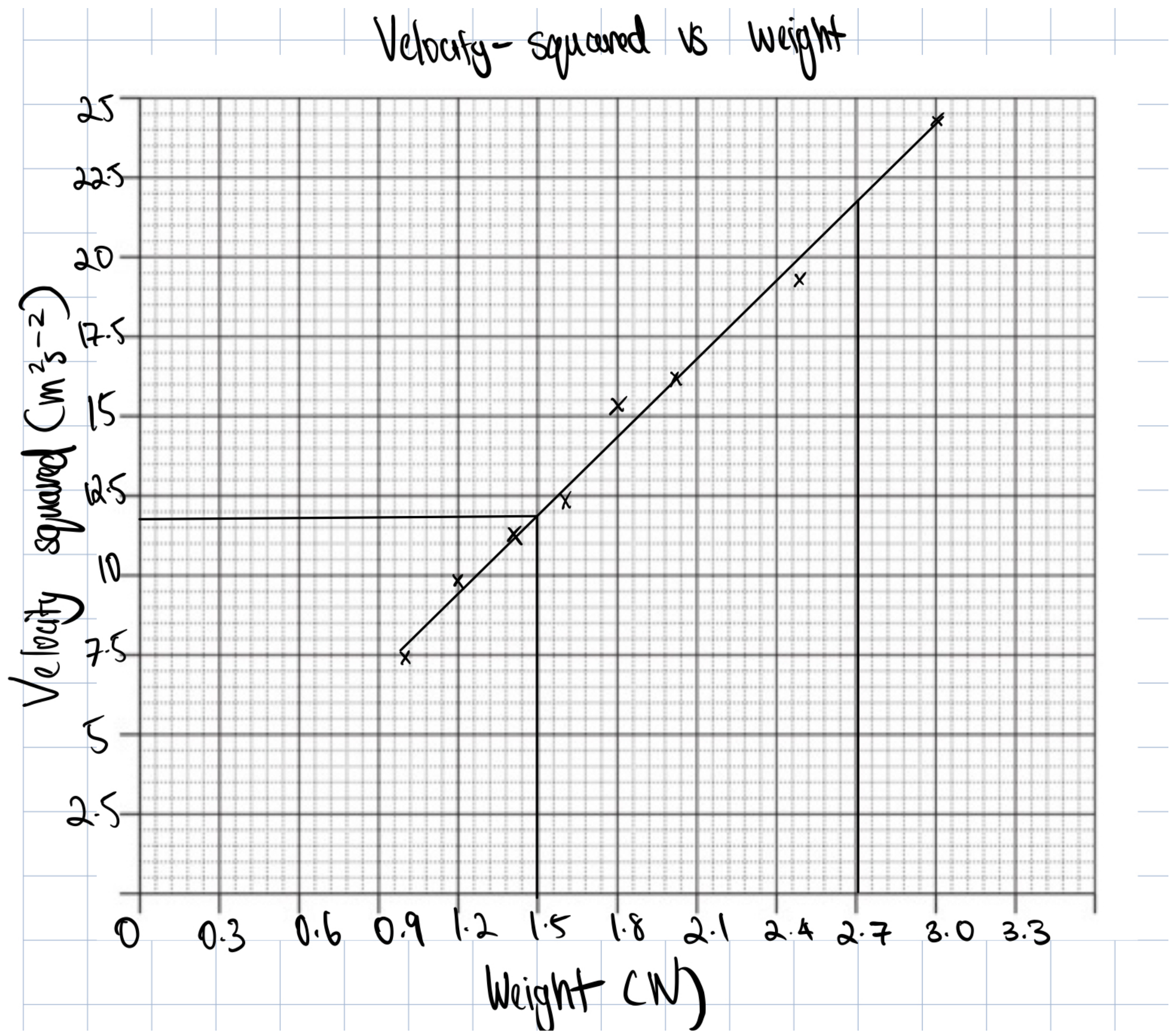
The students' results are shown in the table below.

Weight, F (N)	*Time for 5 revolutions (s)*	*Period, T (s)*	*Radius, r (m)*	*Tangential velocity, v (ms^{-1})*	v^2 *(m^2s^{-2})*
1.0	9.2	1.84	0.80	2.73	7.46
1.2	7.97	1.59	0.80	3.15	9.94
1.4	7.51	1.50	0.80	3.35	11.20
1.6	7.13	1.43	0.80	3.52	12.43
1.8	6.45	1.29	0.80	3.90	15.18
2.0	6.25	1.25	0.80	4.02	16.17
2.5	5.71	1.14	0.80	4.40	19.37
3.0	5.10	1.02	0.80	4.93	24.29

The tangential velocity in each case was determined from the period, T, and the radius, r, using the formula:

$$v = \frac{2\pi r}{T}$$

(a) Using the data given, plot a graph of velocity squared versus weight with a line of best fit. **4**



Question 1 (continued)

(b) List the independent and dependent variables for this experiment. **2**

Dependent: Velocity-squared (m^2s^{-2})

Independent: Weight (N)

(c) Outline two assumptions that the students would make when analysing the experiment. **3**

Are these reasonable assumptions?

1. There is no air resistance
2. The radius of revolution is constant throughout the experiment.

Both these assumptions are likely to be invalid - there is of course air resistance, and the radius will likely change as the mass moves up and down (or if the string is not entirely taut). However, the effect of these two processes is likely small compared to the main result, and therefore we should still get qualitatively similar results when using these assumptions.

(d) Measure the gradient of your graph (with units) and use this value with an appropriate formula to calculate the mass of the rubber stopper. **3**

Show all your working.

$$x_1 = 1.5 \text{ kg}, y_1 = 11.75 \text{m}^2\text{s}^{-2}$$
$$x_2 = 2.7 \text{ kg}, y_2 = 21.75 \text{m}^2\text{s}^{-2}$$

$$\begin{aligned} \text{Gradient} &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{21.75 - 11.75}{2.7 - 1.5} \\ &= 8.3333 \frac{\text{m}^2\text{s}^{-2}}{kg} \end{aligned}$$

$$\begin{aligned} F_g &= Fc \\ F_g &= \frac{mv^2}{r} \\ m &= \frac{F_g \times r}{v^2} \\ m &= \frac{1}{\text{gradient}} \times r \\ m &= \frac{1}{8.33} \times 0.8 \\ m &= 0.096 \text{ kg} \end{aligned}$$

Question 1 (continued)

(e) Outline two possible improvements to the students' method to achieve more reliable results. **2**

Improvement 1: Repeating the experiment 3 times and averaging the results for each weight to get more reliable results.

Improvement 2: Increasing the number of revolutions measured to 10 revolutions, thus reducing random errors (such as reaction time).

(f) Suggest a safety issue that might arise when conducting this experiment, and a way to minimise any risk. **2**

Safety issue: The string holding the rubber stopper may break and release the stopper in a wild manner that may potentially hit students.

Risk minimisation: Move observers (students) to a safe distance of 2 metres away.

(g) How would the graph of velocity squared and weight change if the students instead kept a constant period of T = 1.00 s, while allowing the radius to vary? **2**

Because r is no longer constant, $\frac{mv^2}{r} = F_g$ no longer means that the graph will be a straight line. Instead, we need an equation that only has v^2, F_g, and constants. Rearranging $v = \frac{2\pi r}{T}$ into $r = \frac{vT}{2\pi}$ and substituting this back into $\frac{mv^2}{r} = F_g$, the result is $v = \frac{F_g}{2\pi m}$. This shows us that velocity is proportional to weight and the graph of velocity squared against weight would then become a square root graph.

End of paper