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NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
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QUALIFY FOR THE FUTURE WORLD
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Level 3 Physics, 2016

91524 Demonstrate understanding of mechanical systems

2.00 p.m. Tuesday 15 November 2016
Credits: Six

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of mechanical systems.	Demonstrate in-depth understanding of mechanical systems.	Demonstrate comprehensive understanding of mechanical systems.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Booklet L3–PHYSR.

In your answers use clear numerical working, words and / or diagrams as required.

Numerical answers should be given with an SI unit, to an appropriate number of significant figures.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 10

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QUESTION ONE: CIRCULAR MOTION

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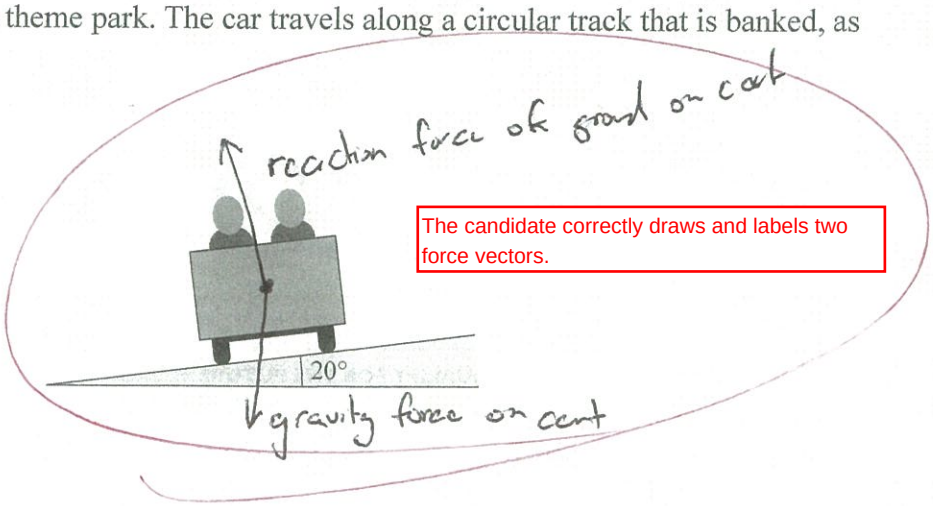
Alice is in a car on a ride at a theme park. The car travels along a circular track that is banked, as shown in the diagram below.

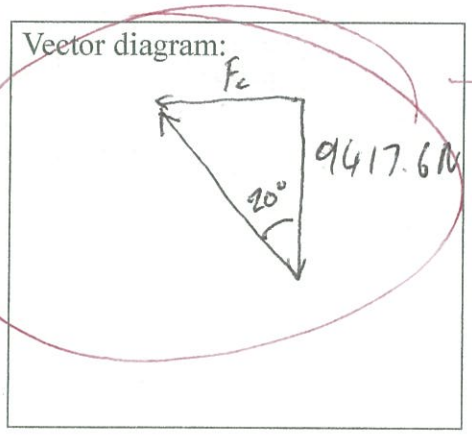


The candidate correctly draws and labels two force vectors.

(a) On the diagram above, draw labelled vectors showing the two forces acting on the car.
You may assume that friction is negligible.

(b) The mass of the car and passengers is 9.60×10^2 kg. The track is banked at an angle of 20°.
Use a vector diagram to calculate the size of the centripetal force on the car.

Vector diagram:



$9.6 \times 10^2 \times 9.81 = 9417.6\text{ N}$ ✓

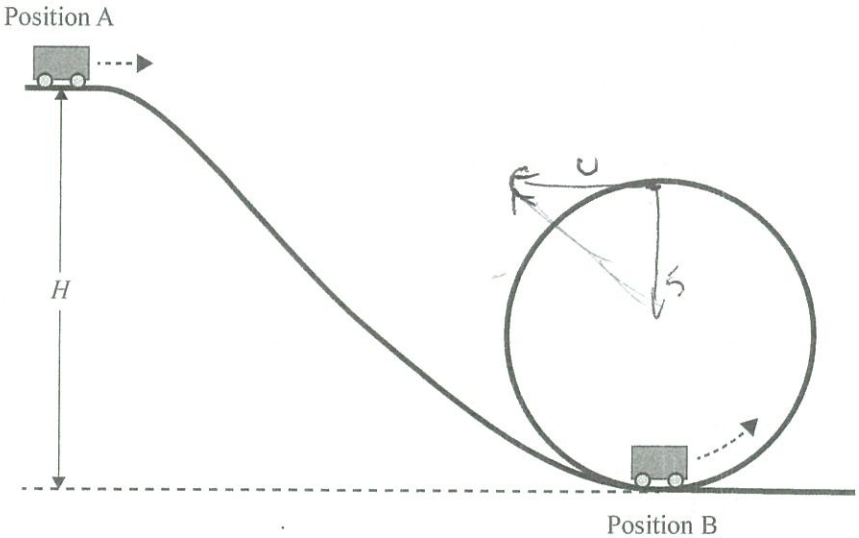
$\tan 20 = \frac{Fc}{9417.6}$

$9417.6 \tan 20 = 3427.7\text{ N}$

$= 3400\text{ N}$ ✓✓

The candidate uses correct vector diagram and the correct working for the size of the centripetal force.

The following diagram shows part of a roller coaster track with the car at two positions.



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(c) Compare the force that the track exerts on the car when the car is at the top of the hill (Position A), with the force that the track exerts on the car when the car is at the bottom of the hill, entering the loop (Position B).

Explain your answer.

Position A the track exerts a smaller force on the car due to a smaller force of gravity acting on it at a higher place which is due to $F_g = \frac{GMm}{r^2}$ for a larger distance from the centre of earth ($\uparrow r$) means smaller F_g smaller r a Position B means larger force of grav so a larger reaction force of track. 11

For an Achieved, the candidate gives partial explanation for both positions.

(d) At the top of the circular loop the force that the track exerts on the car is zero.

Using energy considerations, calculate the height H, of the hill if the radius of the loop is 5.00 m.

You may assume that friction is negligible.

$r = 5$ mass $= 9.6 \times 10^2$ $F_g = 9417.6$ which $F_c =$

$9417.6 = \frac{9.6 \times 10^2 \times v^2}{5}$

$v = 7.004 \text{ ms}^{-1}$ 11 conservation of E

$E_k = E_p$

$E_k = \frac{1}{2} 9.6 \times 10^2 \times 7.004^2$

$= 23546.9$ J $\longrightarrow E_p = 9.6 \times 10^2 \times 9.81 \times h$

$= 2.5$ m

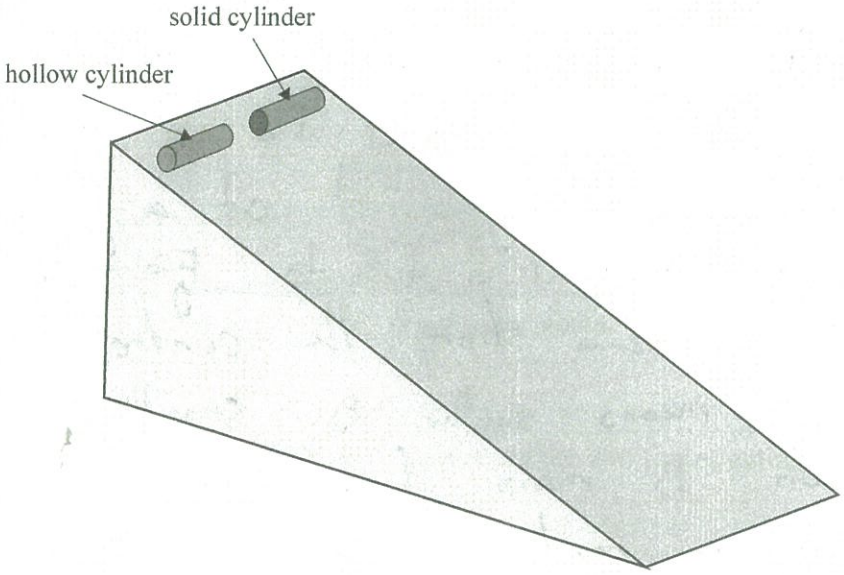
The candidate correctly calculates the speed of the car on top of the loop. For Excellence, the candidate needs to show correct calculation and correct answer for the height H.

M6

QUESTION TWO: ROTATIONAL MOTION

ASSESSOR'S USE ONLY

A solid cylinder and a hollow cylinder of the same shape and mass are rolled down a slope.



(a) State the energy changes that take place as the cylinders roll down the slope.

You may assume that there is negligible heat and sound energy produced.

At the top of the slope they will have maximum gravitational potential energy, as they roll down they lose $E_{p(grav)}$ and it converts in to Kinetic energy more and more kinetic energy

To get an Achieved, the candidate needs to state that gravitational potential energy changes to both linear and rotational kinetic energy.

(b) The hollow cylinder has a radius of 0.058 m. It rolls down the slope, and reaches a speed of 0.250 m s^{-1} at the bottom.

The rotational inertia of the hollow cylinder is 0.140 kg m^2.

Calculate the rotational kinetic energy of the hollow cylinder at the bottom of the slope.

$E_{k(rot)} = \frac{1}{2} 0.14 \times \omega^2$

$\omega = \frac{0.25}{0.058} = 4.31 \text{ rads}^{-1}$

$E = \frac{1}{2} 0.14 \times 4.31^2 = 1.3 \text{ J}$

Correct working and answer.

$a = \frac{v}{t}$ $v = \frac{a}{t}$ acle- t xd

(c) The hollow cylinder starts from rest and has an angular acceleration of 1.72 rad s^{-2}.

Calculate the time taken to complete the first full rotation.

$I = mr^2$ t = ?

$f = \frac{w}{2\pi}$

$\alpha = 1.72$

$w = \alpha \times t$

$I = 0.16$

$J = 0.14 \times 1.72$

$= 0.2408\ Nm^{-1}$

$2\pi r = 0.364$

$r = 0.058$

$a = \frac{2\pi / x}{t}$ $= 1.72 = \frac{2\pi/t}{t}$

$1.72\ rads^{-2} \times 2\pi = 10.8\ revs^{-2}$

$1.72 \times t = 2\pi / t$

$1.72 t^2 = 2\pi$

$2\pi / 1.72$

$\sqrt{3.65} = 1.91s$

Incorrect working and answer.

(d) The solid and the hollow cylinders are both released at the same time from the top of the slope.

Explain why the solid cylinder reaches the bottom of the slope first.

The solid cylinder has its mass more even distributed around the centre of mass this means that it will accelerate at a faster rate and reach top speed quicker

The candidate states one correct idea in terms of mass distribution for solid cylinder. To gain a Merit, the candidate needs to correctly link two ideas by stating that solid cylinder has less rotational inertia since it has all its mass closer to the centre. To gain an Excellence, the candidate needs to correctly link two ideas to conservation of energy or torque.

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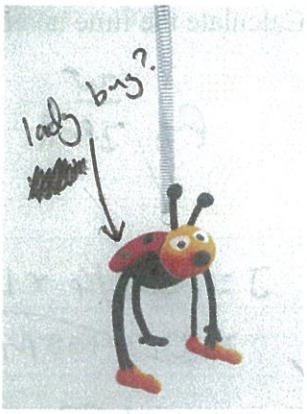
A3

QUESTION THREE: SIMPLE HARMONIC MOTION

ASSESSOR'S USE ONLY

A toy bumble bee hangs on a spring suspended from the ceiling in the laboratory. Tom pulls the bumble bee down 10.0 cm below equilibrium and releases it. The bumble bee moves in simple harmonic motion.



(a) State the two conditions necessary for simple harmonic motion.

the amplitude must be less than the suspending spring. 11

To get an Achieved, the candidate needs to state that the acceleration(or restoring force) is proportional to displacement and acts in the opposite direction to displacement.

(b) The bumble bee's oscillation has a period of 1.57 s.

Calculate the bumble bee's acceleration at time $t = 0.25$ s after Tom releases the bumble bee from the lowest point.

$0.01 \times 4 = 0.04\text{m}$

$v = \frac{d}{t} = 0.04 / 1.57 = 0.0255\text{ms}^{-1}$

$a = \frac{0.0255}{0.25}$

$= 0.09\text{ms}^{-2}$

Incorrect working and answer.

(c) Tom pushes the toy bumble bee with a very small force at regular intervals of time (periodically), so that eventually it is moving up and down with a very large amplitude.

State the name of this phenomenon.

Explain how the bumble bee's motion develops a very large amplitude.

by adding small amounts of force to the bubble bee Tom is increasing its ~~momentum~~ adding momentum to the bumble bee this increased momentum is conserved $p = mv$ mass is constant so the velocity of the bee must increase $v = \frac{d}{t}$ for time remains constant so to conserve momentum the distance the bumble bee travels increases (amplitude)

Incorrect explanation

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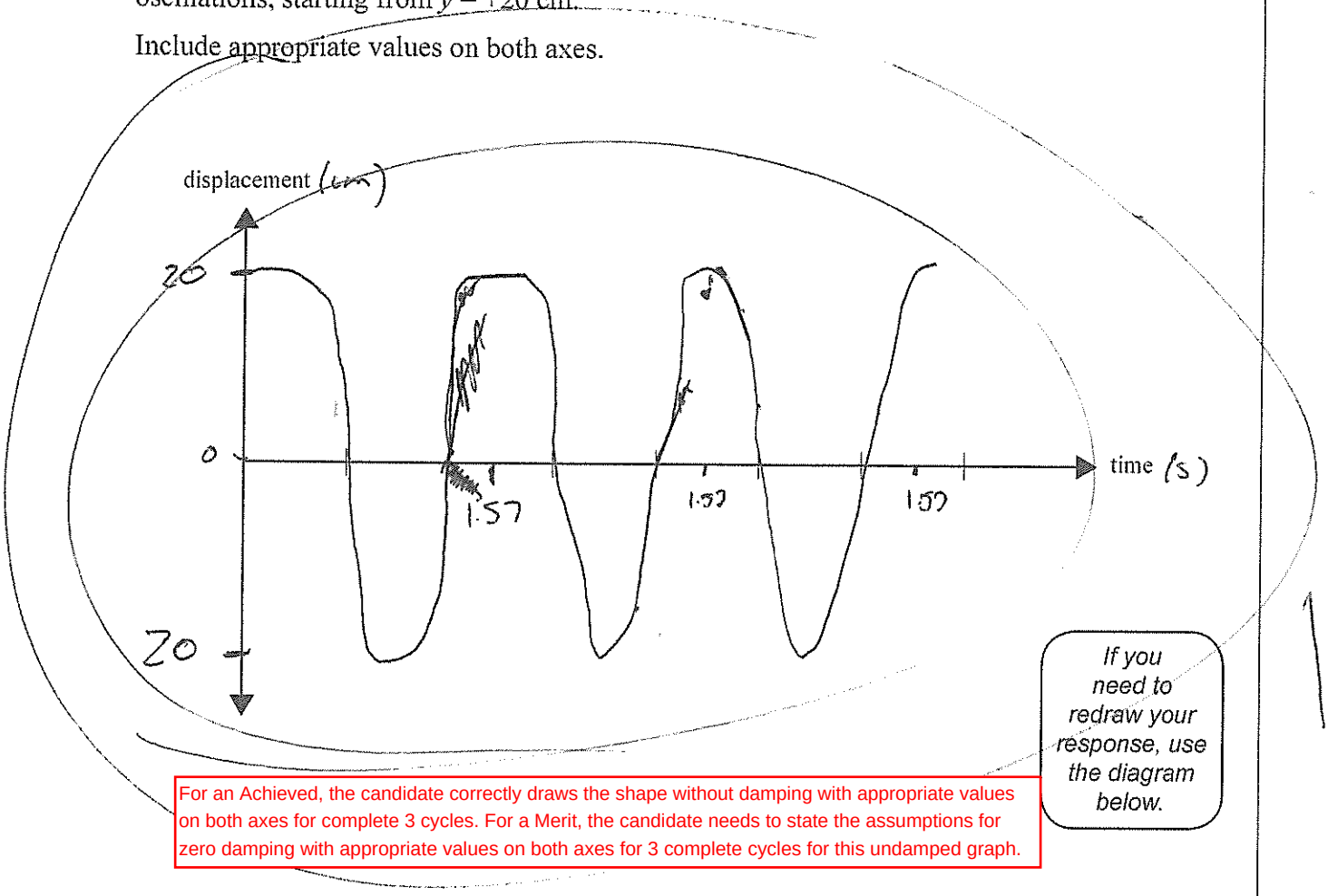
(d) Tom stops pushing the bumble bee when its displacement is 20 cm.

Using the axes given below, draw a graph of displacement against time for three complete oscillations, starting from $y = +20$ cm.

Include appropriate values on both axes.

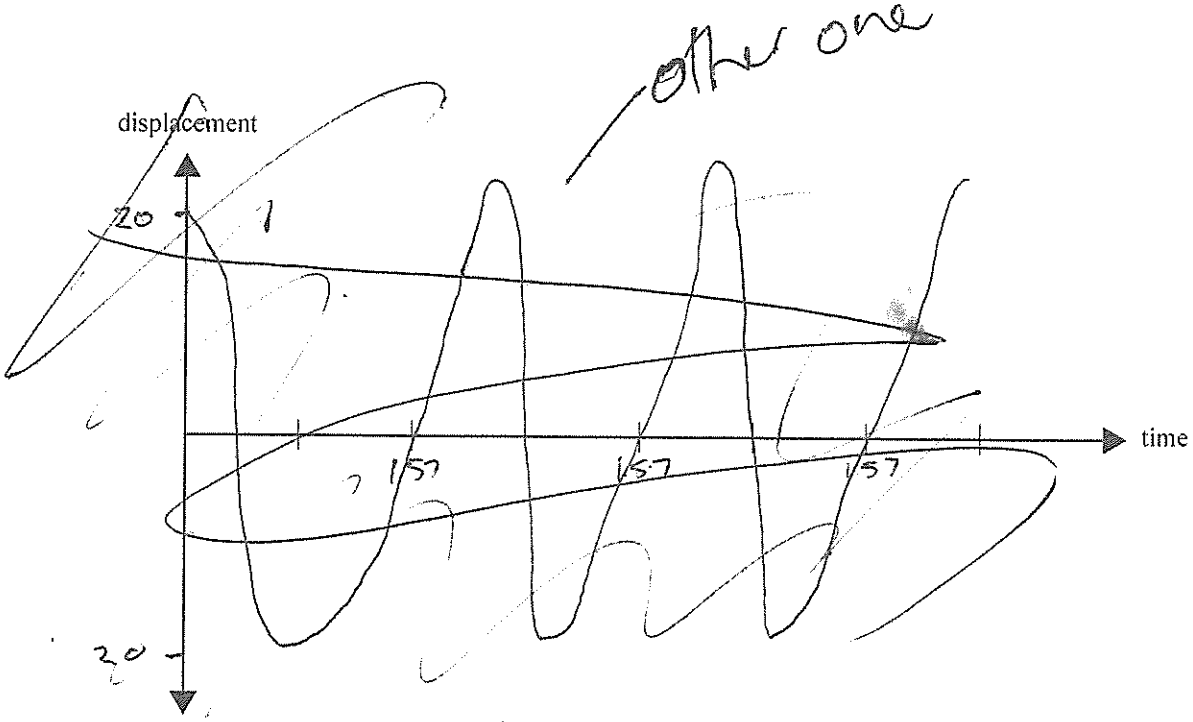


If you need to redraw your response, use the diagram below.

For an Achieved, the candidate correctly draws the shape without damping with appropriate values on both axes for complete 3 cycles. For a Merit, the candidate needs to state the assumptions for zero damping with appropriate values on both axes for 3 complete cycles for this undamped graph.

SPARE DIAGRAM

If you need to redraw your response to Question Three (d), use the diagram below. Make sure it is clear which answer you want marked.



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Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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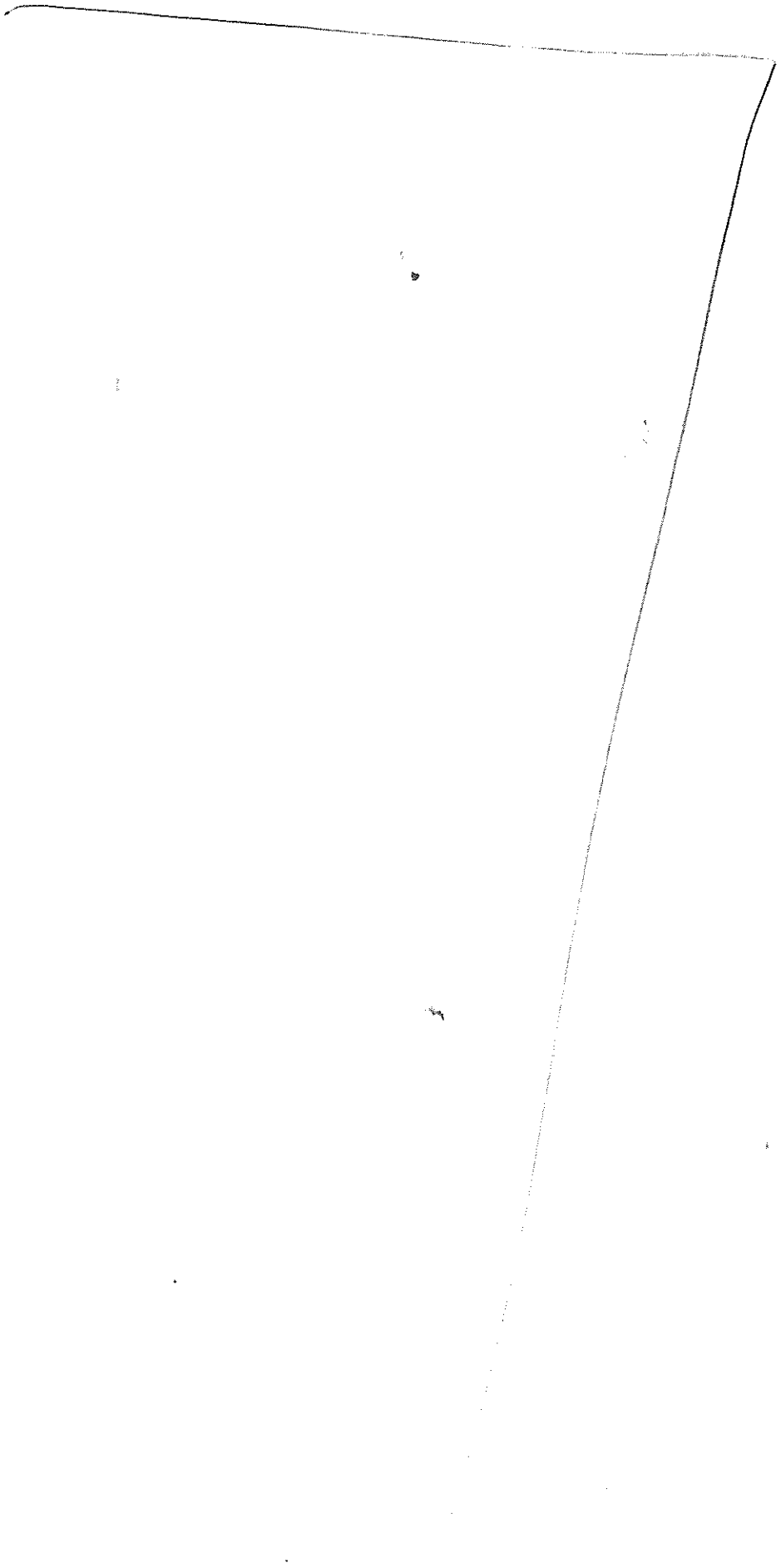

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