SUPERVISOR'S USE ONLY

Tirohia te uhi o muri e kitea ai te whakapākehātanga o tēnei uhi

3

91524M

915245

Tuhia he (☒) ki te pouaka mēnā kāore koe i tuhi kōrero ki tēnei puka

+

NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Te Mātai Ahupūngao, Kaupae 3, 2026

91524M Te whakaatu māramatanga ki ngā pūnaha pūhanga

Ngā whiwhinga: E ono

Paetae	Kaiaka	Kairangi
Te whakaatu māramatanga ki ngā pūnaha pūhanga.	Te whakaatu māramatanga ki ngā pūnaha pūhanga, kia hōhonu.	Te whakaatu māramatanga ki ngā pūnaha pūhanga, kia tōtōpū.

Tirohia kia kitea ai e rite ana te Tau Ākonga ā-Motu (NSN) kei runga i tō puka whakauru ki te tau kei runga ake o tēnei whārangi.

Me whakamātau koe i ngā tūmahi KATOA kei roto i tēnei pukapuka.

Tirohia mēnā kei a koe te Pukapuka Rauemi L3–PHYSMR.

I ō tuhinga, whakaatuhia kia mārama ngā whiriwhiringa tohutau, ngā kupu, ngā hoahoa hoki/rānei, ki ngā wāhi me pērā.

Me hoatu te wae tika o te Pūnaha o te Ao (SI) ki ngā whakautu tohutau.

Mēnā ka hiahia wāhi atu anō koe mō ō tuhinga, whakamahia ngā whārangi wātea kei muri o tēnei pukapuka.

Tirohia kia kitea ai e tika ana te raupapatanga o ngā whārangi 2–23 kei roto i tēnei pukapuka, ka mutu, kāore tētahi o aua whārangi i te takoto kau.

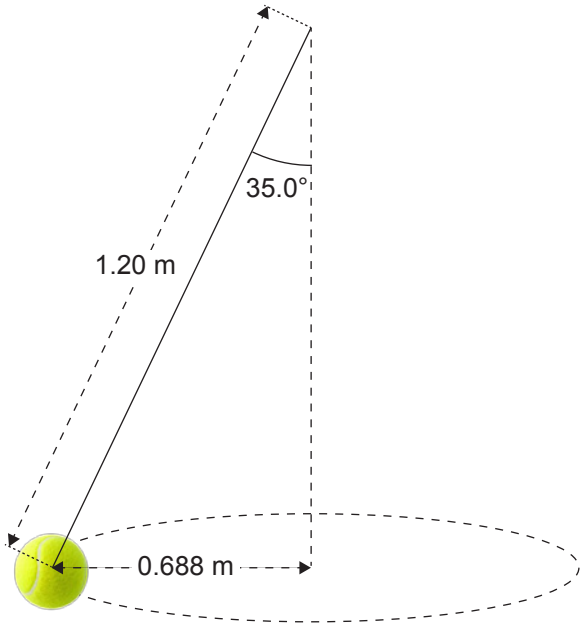
Kaua e tuhi i ngā paenga (////). Ka poroa taua wāhanga ka mākahia ana te pukapuka.

HOATU TĒNEI PUKAPUKA KI TE KAIWHAKAHAERE Ā TE MUTUNGA O TE WHAKAMĀTAUTAU.

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Kāore e whakaaetia ana kia tāruahia tētahi paku wāhanga o tēnei pukapuka ki te kore te Mana Tohu Mātauranga e mātua whakaae.

TE TŪMAHI TUATAHI: TE NEKE POROTAKA ME TE NEKE RITE

Kua herea tētahi pōro tēnehi, e 58.5 g nei tōna papatipu, ki tētahi aho e iti noa nei te papatipu. Ka piua koekotia te pōro e 35.0° ai te koki o te aho ki te poutū. 1.20 m te roa o te aho, ā, 0.688 m te pūtoro o te porowhita ka puta.



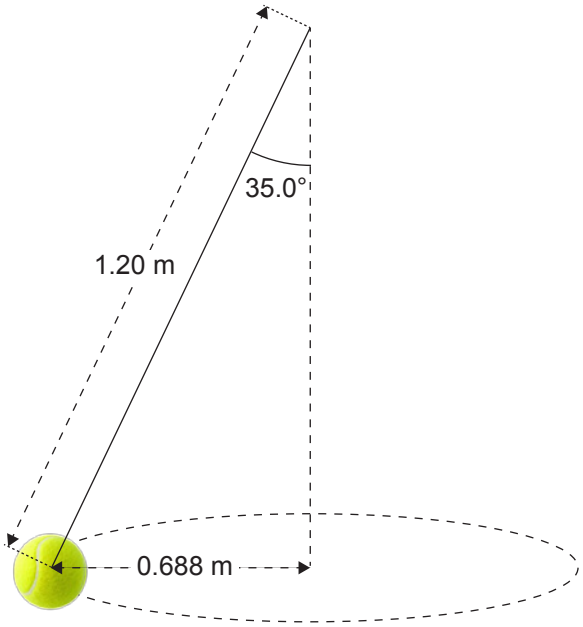
(a) Tāngia tētahi hoahoa tōpana hei whakaatu i ngā tōpana katoa e pā ana ki te pōro i tēnei pūwāhi.

Ki te hiahia koe ki te tā anō i tō urupare, whakamahia te pouaka kei te whārangi 18.

(b) Tātaihia te tere o te pōro tēnehi.

QUESTION ONE: CIRCULAR AND TRANSLATIONAL MOTION

A tennis ball of mass 58.5 g is tied to a string of negligible mass. The ball is swung in a conical motion so the string makes an angle of 35.0° with the vertical. The length of the string is 1.20 m, and the radius of the circle formed is 0.688 m.



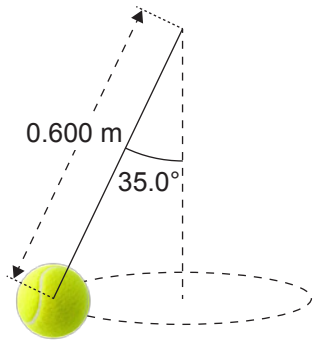
(a) Draw a free body diagram to show all forces acting on the ball at this point.

If you need to redraw your response, use the box on page 19.

(b) Calculate the speed of the tennis ball.

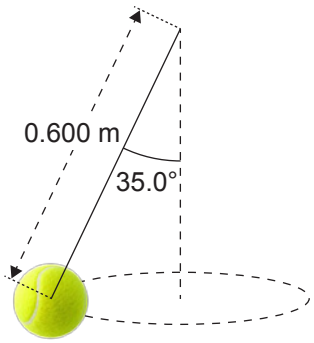
(c) Ka hauruatia te roa o te aho. Ka piua te pōro kia rite te koki ki tērā o mua.

Whakaahuatia, whakamāramahia hoki te āhua o te pānga ki te tōpana whakaroto me te tere o te pōro i te hauruatanga o te aho.



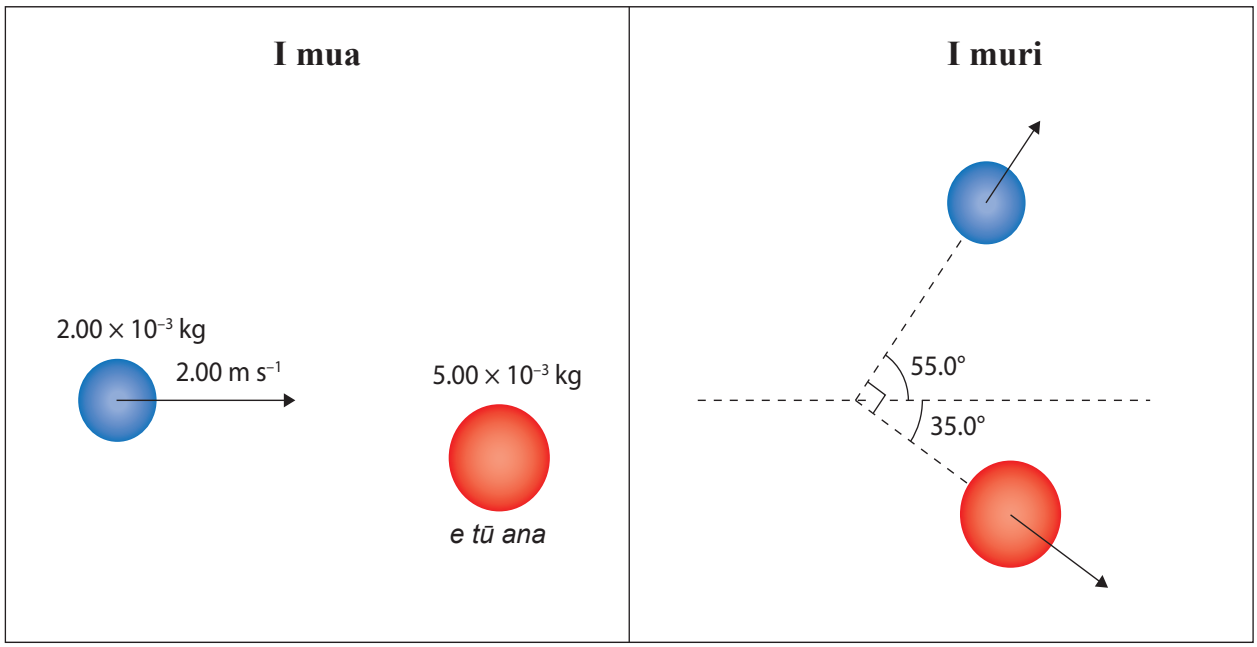
(c) The string is shortened to half its length. The ball is swung, keeping the angle the same as before.

Describe and explain how halving the length of the string will affect the centripetal force and the speed of the ball.



(d) E tākarohia ana tētahi kēmu māpere. Ka tuki atu tētahi māpere kahurangi e iti ana (2.00×10^{-3} kg), e 2.00 m s^{-1} tōna tere whaiahu i te tīmatanga, ki tētahi māpere whero e rahi ana (5.00×10^{-3} kg), e tū ana hoki, ā, e whakaaturia ana ki raro nei te rerenga o ngā māpere e rua. E 55.0° te koki o te rerenga atu o te māpere kahurangi, ā, e 35.0° te koki o te rerenga atu o te māpere whero.

Me kī, kāore he tōpana tapeke e pā ana ki te pūnaha.

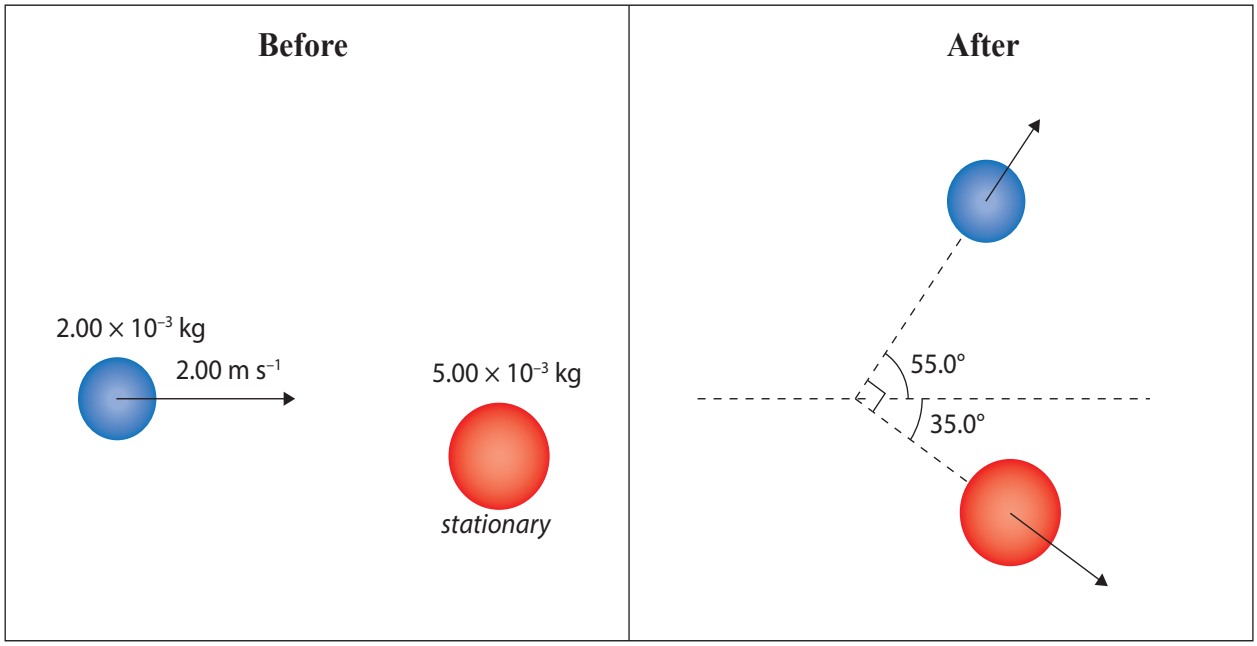


Tātaihia te tere whakamutunga o ngā māpere e rua.

Ka hiahia pea koe ki te tā i tētahi hoahoa pere ki te wāhi kei raro nei.

(d) A game of marbles is being played. A small blue marble (2.00×10^{-3} kg) with initial velocity of 2.00 m s^{-1} collides with a stationary large red marble (5.00×10^{-3} kg), and they move off as shown. The blue marble moves off at an angle of 55.0° and the red marble moves off at an angle of 35.0°.

Assume no net external force acts on the system.



Calculate the final speeds of both marbles.

You may wish to draw a vector diagram in the space below.

TE TŪMAHI TUARUA: TE NEKE HURIHANGA

E tūhura ana a Matt rāua ko Prapthi i te neke. Ka whakanōhia tētahi pōro totoka ki te tihi o tētahi rōnaki, ā, ka tukua. Ka pīrori te pōro me te kore e paheke. Ka tae ana te pōro ki raro, e 22.1 rad s^{-1} tōna tere whaiahu ā-koki. E 50.0 g te papatipu o te pōro, e 5.35 cm tōna pūtoro, e 5.72×10^{-5} kg m^2 tōna tūpuku hurihanga.



(a) Tātaihia te tere whaiahu torotika o te pōro i raro o te rōnaki.

(b) 0.507 s te roa e tae atu ai te pōro ki raro o te rōnaki.

Tātaihia te roa o te rōnaki.

QUESTION TWO: ROTATIONAL MOTION

Matt and Prapthi are investigating motion. A solid ball is placed at the top of a slope and released. The ball rolls without slipping. When the ball reaches the bottom, it has angular velocity of 22.1 rad s^{-1}. The ball has a mass of 50.0 g, a radius of 5.35 cm, and a rotational inertia of 5.72×10^{-5} kg m^2.



(a) Calculate the linear velocity of the ball at the bottom of the slope.

(b) The ball takes 0.507 s to travel to the bottom of the slope.

Calculate the length of the slope.

(c) E noho ana a Matt i tētahi tūru pā ka huri i tētahi tuaka pou i tōna pokapū, e iti noa nei tōna waku. Ka pupuri ia ki tētahi papatipu e 2.00 kg i tēnā, i tēnā o ōna ringa whātoro e rua.

Kei te tūtohi o raro nei te tapeke o ngā tūpuku hurihanga o Matt, o te tūru me ngā papatipu i ngā pūwāhi ringa rerekē e rua.

Te pūwāhi ringa	Te tūpuku hurihanga
Ngā ringa e whātoro ana	E 4.80 kg m^2
Ngā ringa ki roto	1.60 kg m^2

(i) I te tīmatanga, e tau ana a Matt me ōna ringa e whātoro ana. Ka tuku atu a Prapthi i te 14.0 N m o te tōpana whakahuri e pūmau ana mō te 0.350 s, ka tuku ai.

Whakaaturia, ko te 1.02 rad s^{-1} te tere whaiahu ā-koki o Matt i muri tata tonu i te whakakorenga o te tōpana whakahuri.

(ii) Kātahi a Matt ka kume i ōna ringa ki roto.

Whiriwhiria tōna tere whaiahu ā-koki hou.

(c) Matt is sitting on a bar stool that can rotate about a vertical axis through its centre with negligible friction. He holds a 2.00 kg mass in each outstretched hand.

The rotational inertias of Matt, the stool, and masses together at two different arm positions are given in the table below.

Arm position	Rotational inertia
Arms extended	4.80 kg m^2
Arms pulled in	1.60 kg m^2

(i) Matt starts at rest, with his arms extended. Prapthi applies a constant torque of 14.0 N m for a duration of 0.350 s, then lets go.

Show that Matt's angular velocity immediately after the torque is removed is 1.02 rad s^{-1}.

(ii) Matt then pulls his arms in.

Find his new angular velocity.

(d) Ka tīmata ana te huri, mā te kume i ōna ringa ki roto e rerekē ai te tere whaiahu ā-koki o Matt me te tūpuku hurihanga o te pūnaha.

Whakamāramahia kia tōtōpū ngā rerekētanga pūngao ka puta ake i tēnei tukanga.

Me whai wāhi ngā tātaitanga hāngai ki tō tuhinga.

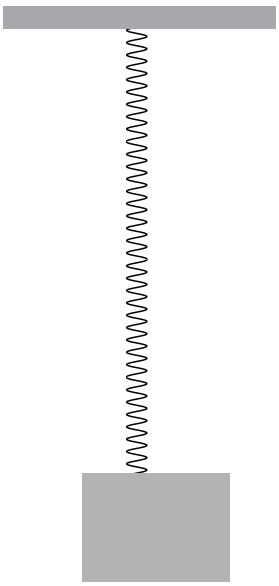
(d) Once spinning, bringing his arms in results in a change to Matt's angular velocity and the rotational inertia of the system.

Explain, fully, the energy changes that occur during this process.

You should include relevant calculations in your answer.

TE TŪMAHI TUATORU: TE NEKE RŌNAKI MĀMĀ

Ka whakamaua tētahi taonga tākaro ngohengohe, ko te 0.250 kg tōna taumaha, ki tētahi pūniko e 3.00 N m^{-1} tōna pūmautanga pūniko. Ka hīkina ki te 0.120 m ki runga ake i tōna tauritenga, kātahi ka tukua. Ka tūpanapana i te neke rōnaki māmā (SHM) i ia 1.81 s.



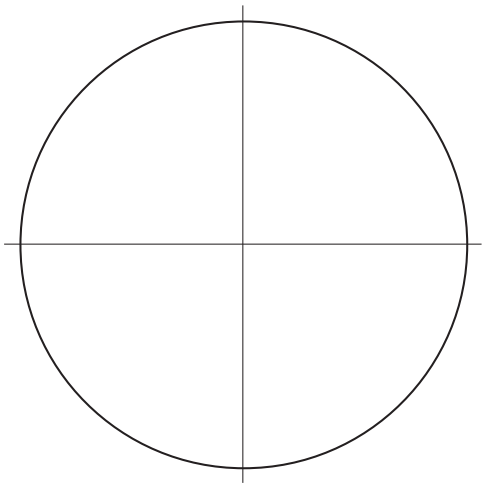
He mea whakahāngai te mea i: https://shop.shorebirds.org.nz/shop/softtoysoundsmall/

(a) Whakaaturia, ko te 3.47 rad s^{-1} te auau ā-koki o te SHM.

(b) Tātaihia te tere whaiahu mōrahi o te taonga tākaro, ā, kōrerotia te pūwāhi o te taonga tākaro i taua wā.

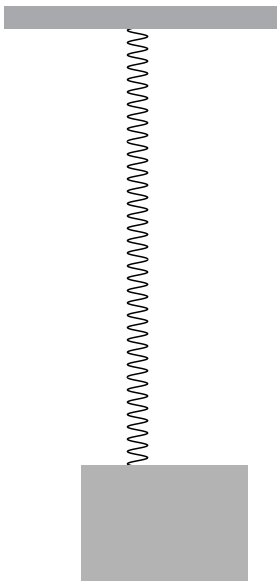
(c) Mā te whakamahi i tētahi porowhita tohutoro, mā ara kē atu rānei, tātaihia te tere whaiahu o te taonga tākaro i tana taenga tuatahitanga ki te peinga 0.0450 m i raro i te tauritenga.

Ki te hiahia koe ki te tā anō i tō urupare, whakamahia te tukutuku kei te whārangi 18.



QUESTION THREE: SIMPLE HARMONIC MOTION

A 0.250 kg soft toy is attached to a spring with a spring constant of 3.00 N m^{-1}. It is raised 0.120 m above its equilibrium position and then released, bouncing up and down in simple harmonic motion (SHM) with a period of 1.81 s.



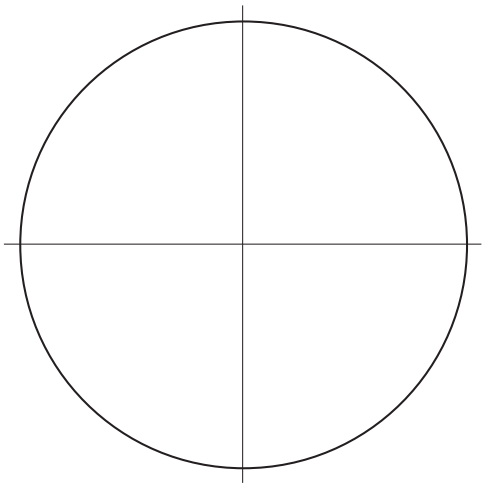
Adapted from: https://shop.shorebirds.org.nz/shop/softtoysoundsmall/

(a) Show that the angular frequency of the SHM is 3.47 rad s^{-1}.

(b) Calculate the maximum velocity of the toy, and state the position of the toy at this point.

(c) By using a reference circle or any other method, calculate the velocity of the toy when it first reaches a displacement of 0.0450 m below the equilibrium position.

If you need to redraw your response, use the grid on page 19.



(d) Ka tūpanapana te taonga tākaro, ā, nāwai, ka tau.

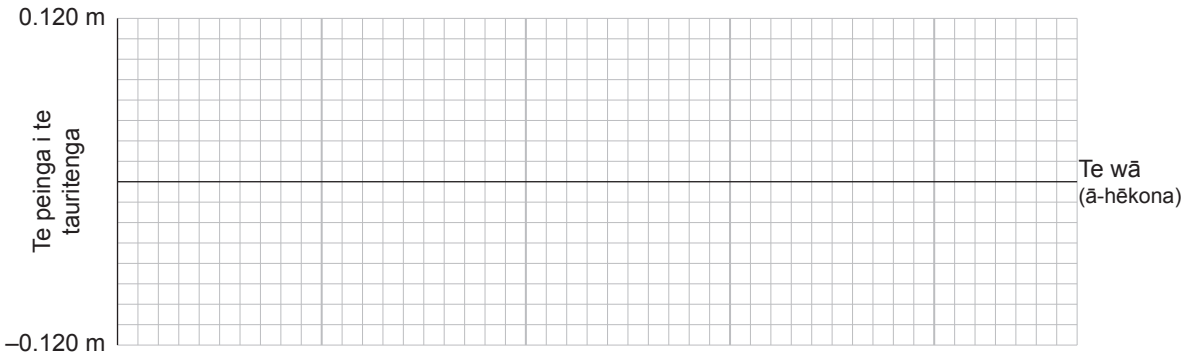
(i) Tapaina tēnei āhuatanga, ā, whakamāramatia te take e tau ai te taonga tākaro ā tōna wā.

Whakaurua te pānga, mehemea he pānga, ki te wā me te teitei o te pūnaha.

(ii) I te tīmatanga, 0.120 m te noho o te taonga tākaro ngohengohe i runga ake i tōna tauritenga.

Tāngia tētahi kauwhata o te peinga i te wā hei whakaatu i te āhua o te rerekē haere o te peinga i ngā nekehanga e toru.

Ki te hiahia koe ki te tā anō i tō urupare, whakamahia te tukutuku kei te whārangi 18



(d) The toy bounces up and down, and eventually comes to rest.

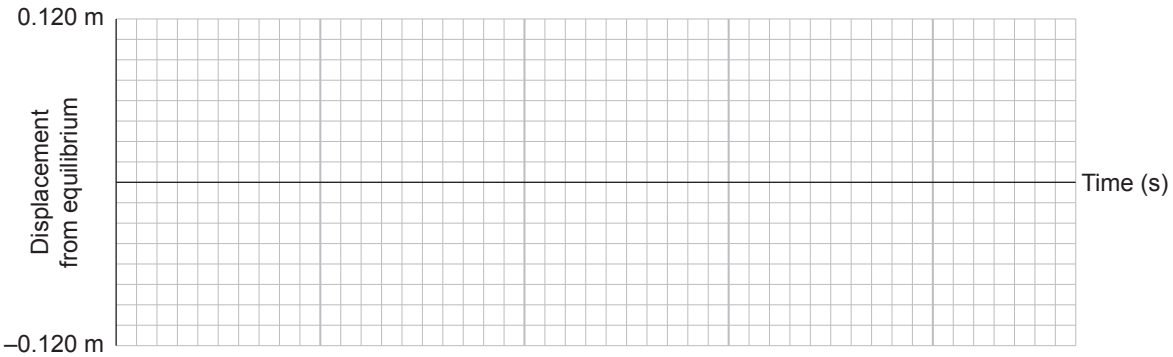
(i) Name this phenomenon and explain why the toy eventually comes to rest.

Include the effect, if any, on the period and amplitude of the system.

(ii) The soft toy was initially 0.120 m above its equilibrium position.

Draw a graph of the displacement against time to show how the displacement changes over three oscillations.

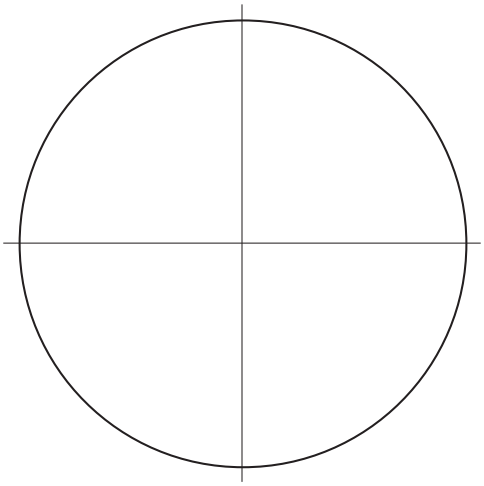
If you need to redraw your response, use the grid on page 19.



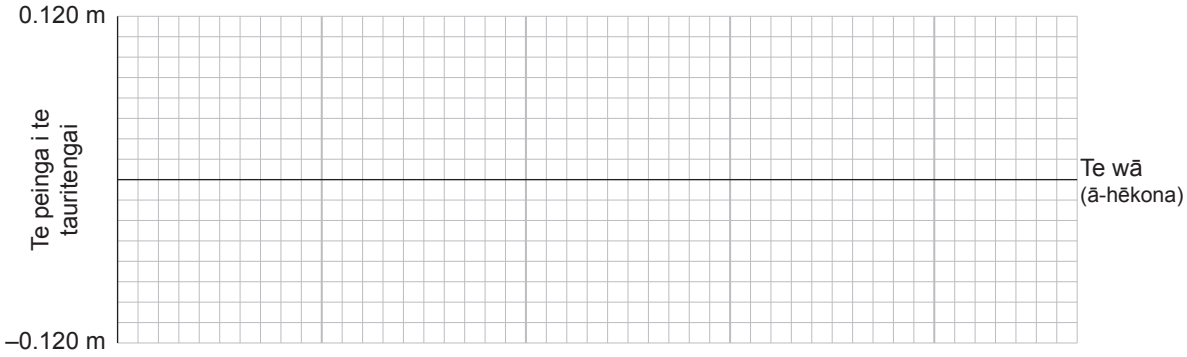
HE HOAHOA WĀTEA

Ki te hiahia koe ki te tā anō i tō urupare ki te Tūmahi Tuatahi (a), whakamahia te pouaka kei raro nei. Kia mārama te tohu i te tuhinga e hiahia ana koe kia mākahia.

Ki te hiahia koe ki te tā anō i tō urupare ki te Tūmahi Tuatoru (c), whakamahia te tukutuku kei raro nei. Kia mārama te tohu i te tuhinga e hiahia ana koe kia mākahia.



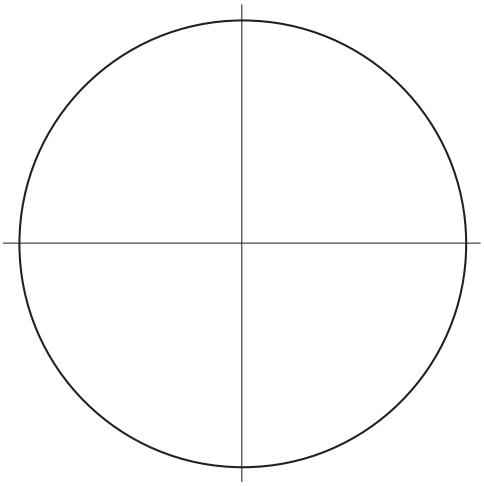
Ki te hiahia koe ki te tā anō i tō urupare ki te Tūmahi Tuatoru (d)(ii), whakamahia te tukutuku kei raro nei. Kia mārama te tohu i te tuhinga e hiahia ana koe kia mākahia.



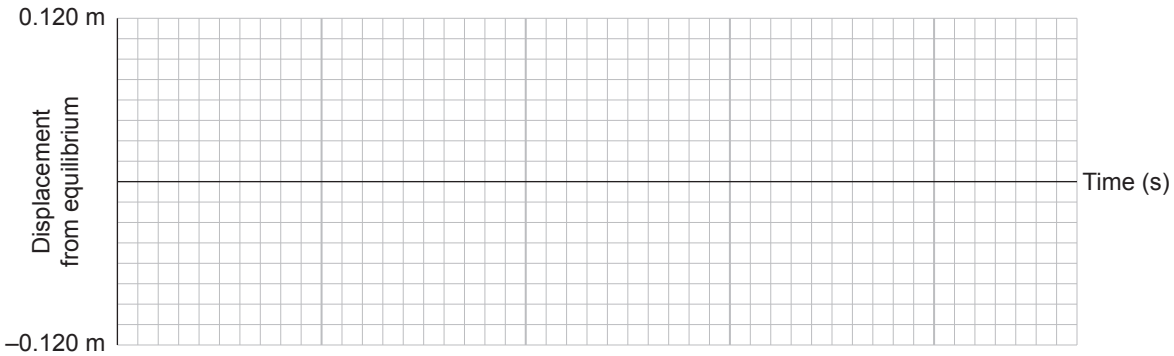
SPARE DIAGRAMS

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

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



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



He whārangi anō ki te hiahiatia.
Tuhia te tau tūmahi mēnā e hāngai ana.

TE TAU TŪMAHI

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

QUESTION NUMBER

He whārangi anō ki te hiahiatia.
Tuhia te tau tūmahi mēnā e hāngai ana.

TE TAU TŪMAHI

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

QUESTION NUMBER

English translation of the wording on the front cover

Level 3 Physics 2026

91524M Demonstrate understanding of mechanical systems

Credits: Six

91524M

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–PHYSMR.

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

Numerical answers should be given with an appropriate SI unit.

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 2–23 in the correct order and that none of these pages is blank.

Do not write in the margins (). This area will be cut off when the booklet is marked.

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