See back cover for an English translation of this cover

3

91524M

915245

SUPERVISOR'S USE ONLY

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Tohua tēnei pouaka mēnā KĀORE koe i tuhituhi i roto i tēnei pukapuka

Ahupūngao, Kaupae 3, 2021

91524M Te whakaatu māramatanga ki ngā pūhanga manawa

Ngā whiwhinga: Ono

Paetae	Kaiaka	Kairangi
Te whakaatu māramatanga ki ngā pūhanga manawa.	Te whakaatu māramatanga hōhonu ki ngā pūhanga manawa.	Te whakaatu māramatanga matawhānui ki ngā pūhanga manawa.

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

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

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

Ki roto i ō tuhinga, whakamahia ngā whiriwhiringa tohutau mārama, ngā kupu, ngā hoahoa hoki, tētahi, ētahi rānei o ēnei, ki hea hiahiatia ai.

Me hoatu te wae tika o te Pūnaha Waeine ā-Ao (SI) ki ngā tuhinga tohutau, ki ngā tau tika o ngā tau tāpua.

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

Tirohia mēnā e tika ana te raupapatanga o ngā whārangi 2–15 kei roto i tēnei pukapuka, ka mutu, kāore tētahi o aua whārangi i te takoto kau.

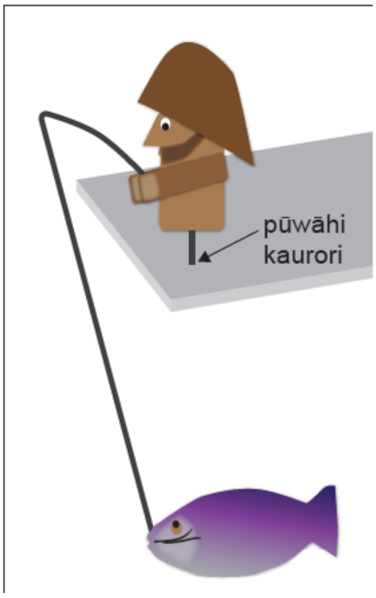
Kaua e tuhi ki ngā wāhi kauruku whakahāngai ( ). Ka tapahia pea tēnei wāhi ina mākahia te pukapuka.

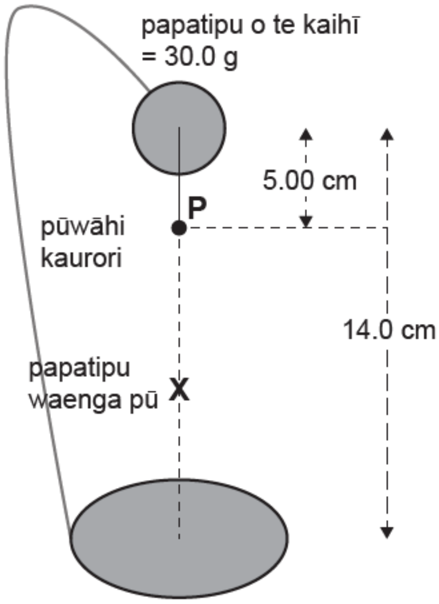
ME HOATU RAWA KOE I TĒNEI PUKAPUKA KI TE KAIWHAKAHAERE Ā TE MUTUNGA O TE WHAKAMĀTAUTAU.

TŪMAHI TUATAHI: TAKAWAIRORE HĪ IKA

Ka taea tētahi takawairore taurite noa te hanga mā te hono i ngā papatipu e rua mā tētahi waea mārō. He tauira te takawairore ‘Kaihī Taurite’ kei raro.

Ka taea te whakatau tata ki ngā papatipu e rua, ka honoa e te waea, e ai ki te hoahoa. Ko te tawhiti i waenga i te pū papatipu o te kaihī me tō te ika he 14.0 cm. Ko te pūwāhi kaurori kei raro o te pou i raro i te kaihī, ā, he 5.00 cm kei raro i te pū papatipu o te kaihī.

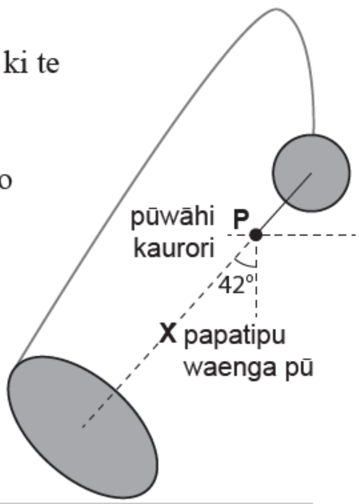




(a) Me kī kāore he papatipu o te waea, me whakaatu ko te pū papatipu (X) o te pūnaha he 3.75 cm (3.75×10^{-2} m) i raro i te pūwāhi kaurori (P), ki te aho e hono ana i te kaihī me te ika.

(b) (i) Ina huria te takawairore i te pū kaurori, ka pā tētahi tōpana whakahuri ki te takawairore nā te tō-ā-papa.

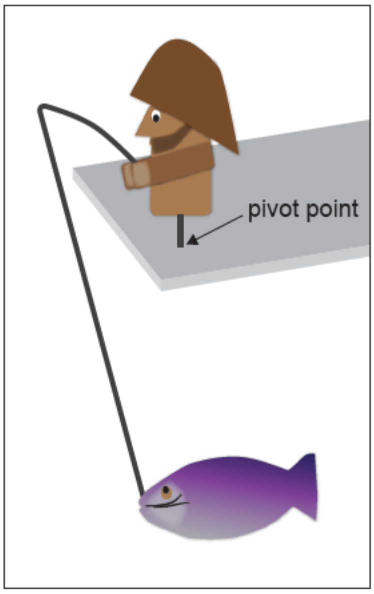
Me whakaatu ina huria te takawairore mā te 42°, e whakaaturia ana, ko te tōpana whakahuri i te pū kaurori he 0.0197 N m.

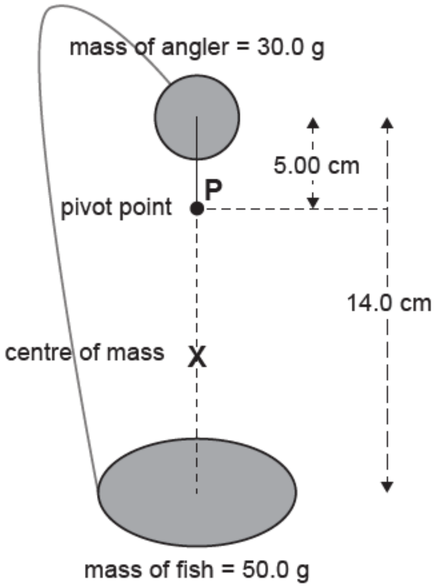


QUESTION ONE: FISHING TOY

A simple balancing toy can be made by joining two masses with a rigid wire. The 'Balancing Angler' toy below is an example.

It can be approximated to two masses, joined by wire, as shown in the diagram. The distance between the centres of mass of the angler and the fish is 14.0 cm. The pivot point is at the bottom of the pole under the angler, and is 5.00 cm below the centre of mass of the angler.

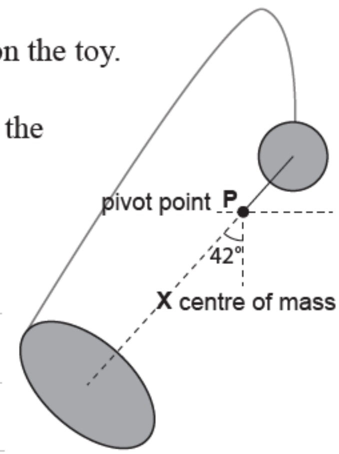




(a) Assuming that the wire has no mass, show that the centre of mass (X) of the system is 3.75 cm (3.75×10^{-2} m) below the pivot point (P), along the line joining the angler and the fish.

(b) (i) When the toy is rotated about the pivot, a torque due to gravity acts on the toy.

Show that when the toy is rotated by 42°, as shown, the torque about the pivot point is 0.0197 N m.

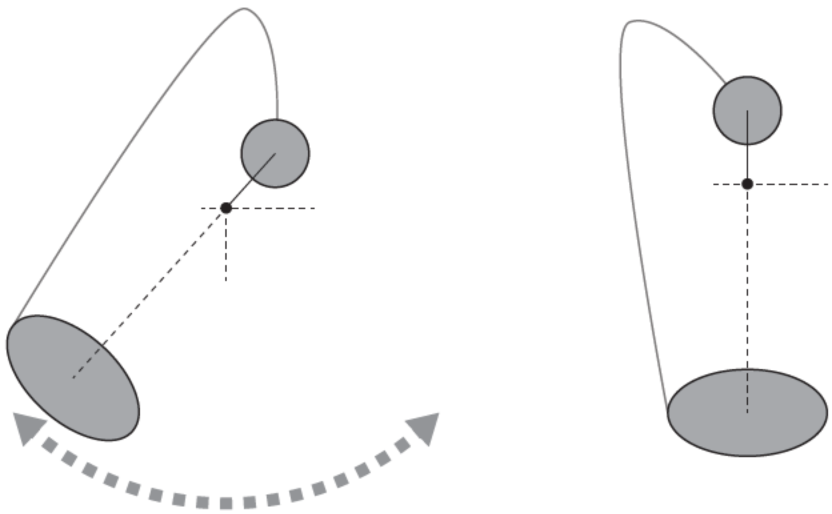


(ii) Ko te tūpuku hurihanga mō te takawairore katoa ko te tapeke o te tūpuku hurihanga o ia papatipu.
Ka taea te tūpuku hurihanga, I, o ia papatipu te whakatau tata mā te whakarite i tēnā, i tēnā hei papatipu pūwāhi, $I = mr^2$, ina ko m te papatipu o te ahanoa, ā, ko r tana tawhiti mai i te pū kaurori.

Whakamahia ngā mōhiohio kua tukuna hei whakatau tata i te tūpuku hurihanga o te takawairore i te pū kaurori, me tana whakahohoro koki ina tukuna mai i te pūwāhi e whakaaturia ana i te wāhanga (i).

(c) Ina tukuna mai te takawairore, ka kōpiupiu engari i te mutunga atu ka tūnoa, ki te pūwāhi okioki e whakaaturia ana i raro.

Matapakina ngā whakawhiti pūngao ka pā i te wā e kōpiupiu ana te takawairore, ā, ka whakamārama i te take he aha e tū ai i ngā wā katoa ki taua pūwāhi tonu.



kōpiupiu o te ika

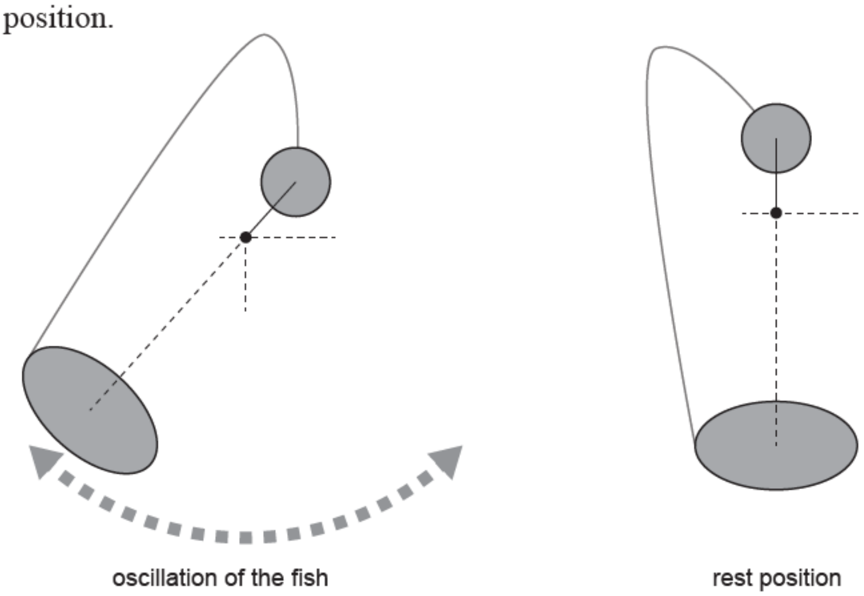
pūwāhi okioki

(ii) The rotational inertia for the whole toy is the sum of rotational inertia of each mass. The rotational inertia, I, of each mass can be estimated by treating each as a point mass, for which $I = mr^2$, where m is the mass of the object and r is its distance from the pivot.

Use the information given to estimate the rotational inertia of the toy about its pivot point, and hence its angular acceleration when it is released from the position shown in part (i).

(c) When the toy is released, it oscillates but eventually ends up stationary, in the rest position shown below.

Discuss the energy transfers that occur while the toy is oscillating, and explain why it always stops in that exact position.



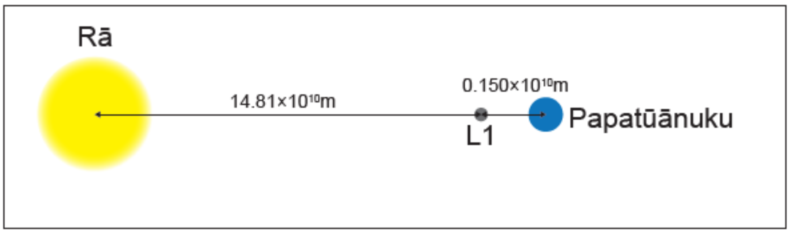
TŪMAHI TUARUA: KEI TĒTAHI ĀMIONGA REREKĒ TE AMIORANGI

Papatipu o Tamanuiterā = 1.99×10^{30} kg

Papatipu o Papatūānuku = 5.97×10^{24} kg

Ko te amiorangi a te Deep Space Climate Observatory kei tētahi āmionga tino rerekē o te Rā, i te pūwāhi L1. I tēnei pūwāhi ka kukume te amiorangi ki te Rā me Papatūānuku, ā, he pūmau te āmionga i te Rā i te wā ōrite ki a Papatūānuku, kia noho ai ki waenga i te Rā me Papatūānuku i ngā wā katoa.

Ko te amiorangi he 14.81×10^{10} m mai i te Rā me te 0.150×10^{10} m mai i a Papatūānuku.



E whakaatu ana te hoahoa māmā (kāore i te āwhatatia) i te tūnga o te pūwāhi L1 e hāngai ana ki te Rā me Papatūānuku.

(a) E kī ana tētahi tuhipānui moheni ko te pūwāhi L1 te wāhi e taurite ai ngā tōpana tō-ā-papa o te Rā me Papatūānuku.

Me whakamārama i te take kāore e tika tēnei mēnā e neke ana te amiorangi ki te āmionga porohita pūmau.

(b) Ko te amiorangi, nā te pūwāhi L1 i waenga i a Papatūānuku me te Rā, kei raro i te kukume o te whaitua tō-ā-papa o te Rā me tō Papatūānuku.

Me whakaatu ko te kaha whaitua tō-ā-papa tapeke, g, i te pūwāhi L1 kei te amiorangi, mēnā kei te amionga porowhita, ā, e ōrite ana ki te wā amio o tētahi tau Papatūānuku (3.1536×10^7 s), he 5.88×10^{-3} N kg^{-1}.

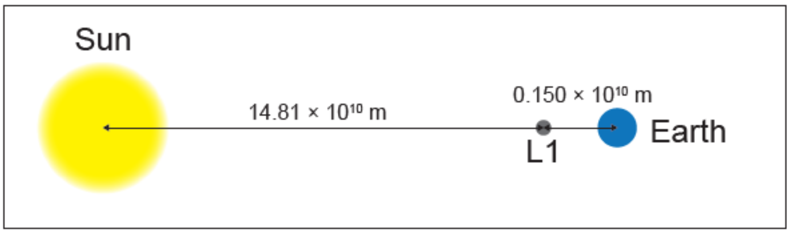
QUESTION TWO: A SATELLITE IN AN UNUSUAL ORBIT

Mass of the Sun = 1.99×10^{30} kg

Mass of the Earth = 5.97×10^{24} kg

The Deep Space Climate Observatory satellite is in a very unusual orbit of the Sun, at the L1 point. In this position the satellite is attracted to both the Sun and the Earth, and it is in a stable orbit around the Sun with the same period as the Earth, keeping it always between the Sun and the Earth.

The satellite is 14.81×10^{10} m from the Sun and 0.150×10^{10} m from the Earth.



Simplified diagram (not to scale) showing the position of the L1 point relative to the Sun and Earth.

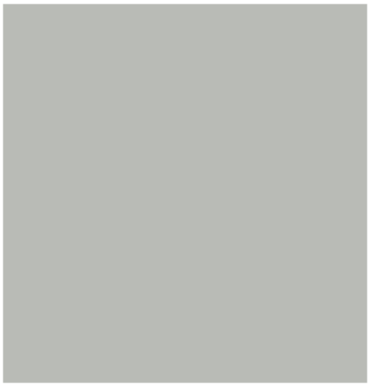
(a) A magazine article states that the L1 point is where the gravitational forces of the Sun and the Earth are balanced.

Explain why this cannot be true if the satellite is moving in a stable circular orbit.

(b) The satellite, due to its L1 position between the Earth and the Sun, is under the influence of the gravitational field of the Sun as well as that of the Earth.

Show that the net gravitational field strength, g, at position L1 on the satellite, if it is moving in a circular orbit and is consistent with it having a period of an Earth year (3.1536×10^{7} s), is 5.88×10^{-3} N kg^{-1}.

(c) He kāmera motuhake ō te amiorangi e tohu ana ki te Rā me Papatūānuku, kia pai ai te huri me tētahi wā huri o te kotahi tau i Papatūānuku kia hāngai ai ki ēnei ahanoa i te āmionga o te Rā. Ka taea ngā papa hiko kōmaru kei te amiorangi te neke kia tata atu, kia tawhiti mai rānei i te amiorangi hei whakatika i te wā huri.



He mea urutau mai i: https://en.wikipedia.org/wiki/Deep_Space_Climate_Observatory#/media/File:DSCOVR_spacecraft_model.png

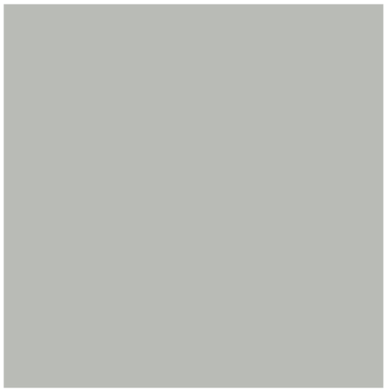
Whakamāramahia mai he pēhea te pānga o te neke kia tawhiti atu ngā papa hiko kōmaru mai i te amiorangi ki te tere koki.

(d) Ka tuki tētahi korakora iti o tētahi unahiroa tio ki te amiorangi, ā, ka piri ki tētahi o ngā papa kōmaru hiko i te tawhiti o te 1.42 m mai i te pou tāwhirowhiro. He 0.780 kg te papatipu o taua korakora me te whakapiki i te tere koki o te amiorangi mā te 0.0124 rad s^{-1}. Ko te whakatau tata o te tūpuku hurihanga (me te korakora) o te amiorangi he 179 kg m^2.

Whakatauhia te tere tūtuki o te korakora (e hāngai ana ki te āmiorangi).

(c) The satellite has special cameras pointing at the Sun and at the Earth, so it has to spin with a period of one Earth year to keep in line with these objects as it orbits the Sun. The solar panels on the satellite could be moved closer or further from the satellite to adjust the spin period.

Explain how moving the solar panels further from the satellite would affect its angular velocity.

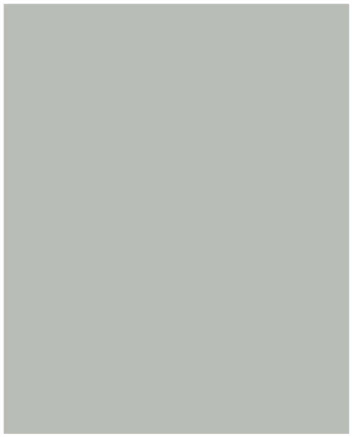


Adapted from: https://en.wikipedia.org/wiki/Deep_Space_Climate_Observatory#/media/File:DSCOVR_spacecraft_model.png

(d) A small fragment of an icy comet hits the spacecraft and sticks to one of the solar panels at a distance of 1.42 m from the axis of rotation. The fragment has a mass of 0.780 kg and it increases the angular velocity of the satellite by 0.0124 rad s^{-1}. The satellite (with the fragment) is estimated to have a rotational inertia of 179 kg m^2.

Determine the impact speed of the fragment (relative to the satellite).

TŪMAHI TUATORU: PŪNIKO WAKA



https://educalingo.com/zh/dic-de/einzelradaufhangung

Ka whakanohohia e te pūnaha pūniko waka māmā te taumaha o te motukā ki ngā pūniko e whā – e mau ana tēnā me tēnā ki tētahi wīra. Ko te papatipu o te waka he 893 kg.

Ka noho a Jon ki te tuanui, ki waenga o te motukā, kātahi ka reti mai, ā, ka tūpato tana tere tuku i tōna taumaha mai i te motukā me te kore e pēhi ki raro. Ka mātakitaki ia e te motukā e tōiriiri whakarunga, whakararo ana. Ka tutuki te tōiriiri kotahi i roto i te 1.14 s.

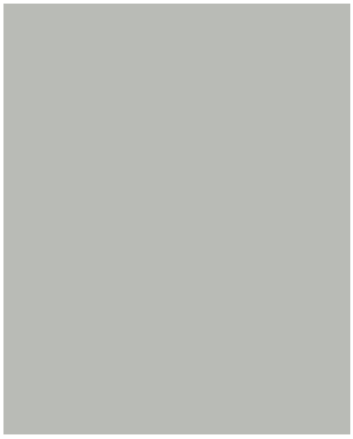
He mea urutau mai i: www.seekpng.com/ipng/u2r5t4a9a9q8a9r5_side-view-of-the-car-hd-car-side/

(a) Me whakaatu te pūmau pūniko mō te pūnaha pūniko-whā tōpū he 2.71×10^4 N m^{-1}.

(b) Ka whakaaroaro a Jon mēnā kei te neke te motukā mā te nekehanga hāwarite māmā (SHM).

Tuhia ngā āhuatanga mō te SHM.

QUESTION THREE: CAR SUSPENSION



https://educalingo.com/zh/dic-de/einzelradaufhangung

A simple car suspension system rests the weight of the car onto four springs – each attached to a wheel. The car has a mass of 893 kg.

Jon sits on the roof, in the middle of the car, then slides off, careful to quickly release his weight from the car without pushing down on it. He watches the car oscillate up and down. It completes one oscillation in 1.14 s.

Adapted from: www.seekpng.com/ipng/u2r5t4a9a9q8a9r5_side-view-of-the-car-hd-car-side/

(a) Show that the spring constant for the combined four-spring system is 2.71×10^4 N m^{-1}.

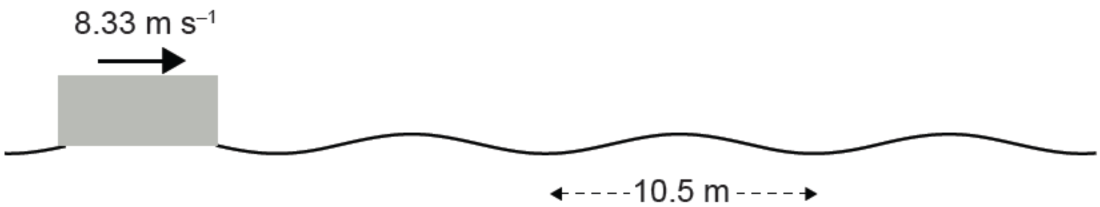
(b) Jon wonders whether the car body is moving with simple harmonic motion (SHM).

State the conditions for SHM.

(c) He 103 kg te papatipu o Jon, ā, i a ia e noho ana i runga i te tuanui, he ōrite te tautoko i tana taumaha e ngā wīra e whā.

Whakatauhia te teitei tīmata o te tōiriiringa, me te whakahohoro mōrahi o te motukā ina tōiriiri ana.

(d) Haere tahi ai a Jon rāua ko tōna hoa a Rick i roto i te motukā. He 10.5 m te tawhiti o ngā puku whakapōturi kei te rori tētahi i tētahi. Ina haere ana te motukā i te 8.33 m s^{-1}, ka nui haere atu ngā tōiriiringa poutū.



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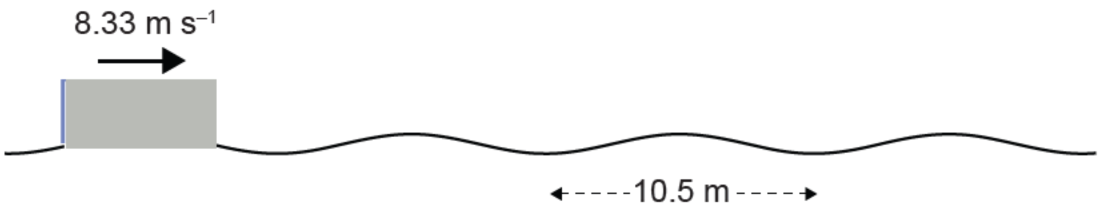
Whakamāramahia mai he aha e pā mai ai tēnei, ka whakatau i te papatipu o Rick.

(c) Jon has a mass of 103 kg, and while he sat on the roof, his weight was supported by each of the four wheels equally.

Determine the initial amplitude of the oscillation, and hence the maximum acceleration of the car as it oscillates.

(d) Jon and his friend Rick ride in the car together. Speed bumps in the road are 10.5 m apart. When they are travelling at 8.33 m s^{-1}, the car builds up large vertical oscillations.



Adapted from: www.seekpng.com/ipng/u2r5t4a9a9q8a9r5_side-view-of-the-car-hd-car-side/

Explain why this happens, and determine Rick's mass.

He whārangi anō ki te hiahiatia.
Tuhia te (ngā) tau tūmahi mēnā e tika ana.

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 2021

91524M Demonstrate understanding of mechanical systems

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.

91524M

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 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 2–15 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area ( ). This area may be cut off when the booklet is marked.

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