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91524M

915245

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

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

SUPERVISOR'S USE ONLY

Ahupūngao, Kaupae 3, 2018

91524M Te whakaatu māramatanga ki ngā pūhanga manawa

2.00 i te ahiahi Rātū 20 Whiringa-ā-rangi 2018
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 2–19 kei roto i tēnei pukapuka, ka mutu, kāore tētahi o aua whārangi i te takoto kau.

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

TAPEKE

MĀ TE KAIMĀKA ANAKE

MĀ TE KAIMĀKA ANAKE

TŪMAHI TUATAHI

Papatipu o Papatūānuku = 5.97×10^{24} kg
Pūtoro o Papatūānuku = 6.37×10^{6} m

Kua tīmata te kamupene o Aotearoa nā rātau i hanga te Electron Rocket ki te whakarewa arumoni i ngā amiorangi mai i te Te Māhia i Te Matau-a-Māui. Ka taea e te tākirirangi te kawe te amiorangi, he 1.50×10^{2} kg te papatipu, kia pūmau, kia porohita te āmionga i te 5.00×10^{5} m i runga ake i te mata o Papatūānuku.

(a) Me whakaatu ko te tōpana nā te tō-ā-papa ki te amiorangi i tēnei āmionga he 1270 N.

(b) Ka ōrite te tere o te haere o te tākirirangi, te amiorangi, me ngā para tuarangi i te tiketike ōrite, i ngā āmionga pūmau, porohita anō hoki.

Me whakaatu e tika ana tēnei i ngā wā katoa mā te kimi i te tātai mō te tere o te āmionga:

$v_{\text{āmionga}} = \sqrt{\frac{Gm}{r}}$, ka whakamahi i tēnei hei whakatau i te tere o te āmionga o te amiorangi.

ASSESSOR'S USE ONLY

QUESTION ONE

Mass of the Earth	$= 5.97 \times 10^{24}$ kg
Radius of the Earth	$= 6.37 \times 10^{6}$ m

The Electron Rocket developed by New Zealand company Rocket Lab has begun commercial launches of satellites from the Mahia Peninsula in Hawke's Bay. The rocket can carry a satellite of mass 1.50×10^{2} kg to a stable, circular orbit 5.00×10^{5} m above the Earth's surface.

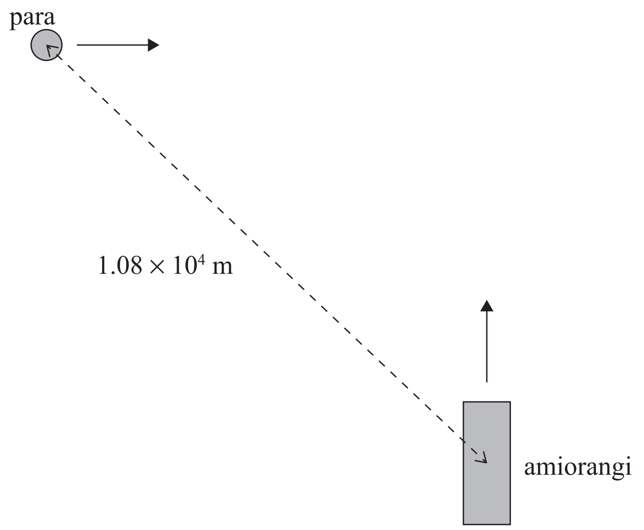
(a) Show that the force due to gravity on the satellite in this orbit is 1270 N.

(b) The rocket, the satellite, and any space debris at the same altitude in stable, circular orbits, will all travel at the same speed.

Show that this is always true by deriving the formula for orbital velocity:

$v_{\text{orbit}} = \sqrt{\frac{Gm}{r}}$, and use this to determine the orbital velocity of the satellite.

E haere ana tētahi para tuarangi 20.0 kg i te tiketike me te tere ōrite ki te amiorangi engari ki tētahi ahunga he 90° ki te tere o te amiorangi. I te wā e whakaaturia ana ki te hoahoa i raro, he 1.08×10^4 m te tawhiti o te para i te amiorangi.



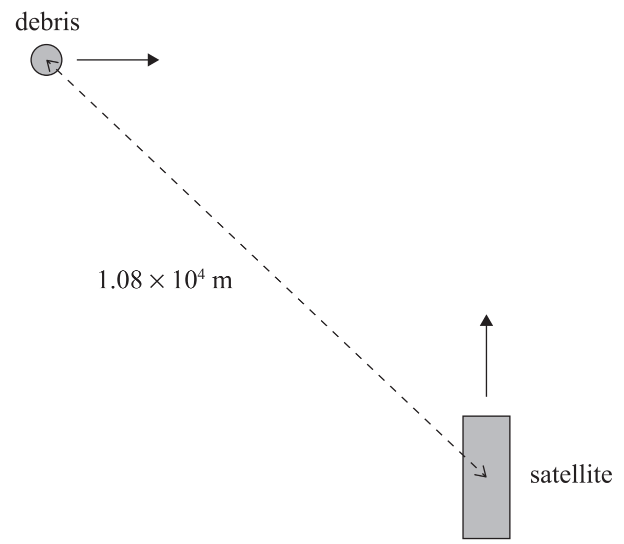
(c) (i) Tātaihia te tawhiti i waenganui i te waenga pū o te papatipu o te pūnaha me te amiorangi.

(ii) Whakaahuahia te nekehanga o te waenga pū o te papatipu o te pūnaha i te wā e neke haere tonu ana te para me te amiorangi i te ara o tēnā, o tēnā.

Parahautia tō urupare.

ASSESSOR'S USE ONLY

A 20.0 kg piece of space debris is travelling at the same altitude and speed as the satellite but in a direction that is 90° to the satellite's velocity. At the moment shown in the diagram below, the debris and the satellite are 1.08×10^4 m apart.



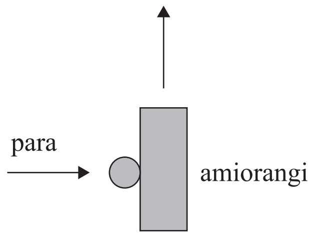
(c) (i) Calculate the distance between the centre of mass of the system and the satellite.

(ii) Describe the motion of the centre of mass of the system as the debris and satellite continue to move along their paths.

Justify your response.

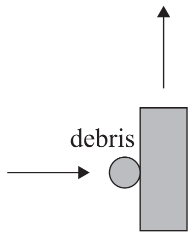
MĀ TE KAIMĀKA ANAKE

(d) Ka tuki te para, ā, ka mau ki te amiorangi.



Tātaihia te tere me te ahunga (e pā ana ki te ahunga tuatahi o te amiorangi) o te amiorangi me te para kua mau.

(d) The debris collides and becomes embedded in the satellite.



Calculate the speed and direction (relative to the initial direction of the satellite) of the satellite and embedded debris.

ASSESSOR'S USE ONLY

MĀ TE KAIMĀKA ANAKE

TŪMAHI TUARUA

Ka taea ngā amiorangi huarere te whakarewa kia huri amio i ngā tōpito Whakararo me te Whakarunga. Mā tēnei ka taea e te kāmera o te amiorangi te whānuitanga o te mata o Papatūānuku te titiro i te wā e hurihuri ana a Papatūānuku i raro. Ko te wā amio o tētahi amiorangi huarere noa he 101 meneti.

www.metoffice.gov.uk/learning/making-a-forecast/first-steps/obs-from-space

(a) Me whakaatu, kia anga tonu atu te kāmera ki te mata o Papatūānuku, me mātua hurihuri te amiorangi ki tētahi tere koki o te 1.04×10^{-3} rad s^{-1}.

Ka taea tēnei tere koki mā te whakaharuru i ngā pūwhakatoro 5.00 N e rua kei tētahi taha, kei tētahi taha o te whitianga 1.60 m o te amiorangi.

(b) Whakamāramahia te take me mātua whakamahi kē ko ngā pūwhakatoro e rua, te whakamahi rānei i te mea kotahi i tētahi taha o te amiorangi, ka mutu he tōpana huarua.

(c) Ka whakaharuruhia ngā pūwhakatoro mō te 6.48×10^{-3} s kia hurihuri ai te amiorangi ki te tere koki e hiahiatia ana.

Whakaaturia ko te tūpuku hurihuri o te amiorangi he 50.0 kg m^2.

ASSESSOR'S USE ONLY

QUESTION TWO

Weather satellites can be launched into orbits that circle around the North and South poles. This enables the satellite's camera to view the whole of the Earth's surface as the Earth spins underneath. The orbital period of a typical weather satellite is 101 minutes.

www.metoffice.gov.uk/learning/making-a-forecast/first-steps/obs-from-space

(a) Show that in order to keep the camera pointed towards the Earth's surface, the satellite must spin at an angular velocity of 1.04×10^{-3} rad s^{-1}.

This angular velocity is achieved by firing two 5.00 N thrusters attached on opposite sides of the satellite's 1.60 m diameter.

(b) Explain why two thrusters must be used rather than simply one on one side of the satellite with double the thrust force.

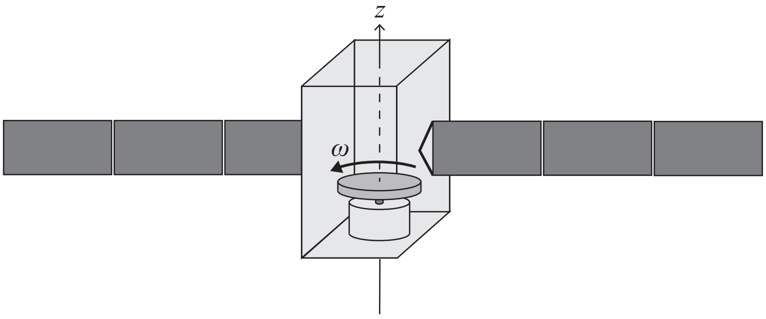
(c) The thrusters are fired for 6.48×10^{-3} s to set the satellite rotating at the required angular velocity.

Show that the rotational inertia of the satellite is 50.0 kg m^2.

(d) Tē whakamahi ai i ngā pūwhakatoro e rua hei whakahāngai i te tere koki o tētahi amiorangi, ko te tikanga ka pai ake te whakamahi i tētahi pūnaha “wīra kōaro”. Ina tīmata te wīra ki te hurihuri ki te ahunga kotahi, ka huri te amiorangi ki te ahunga kōaro.

He toka te wīra, ā, ko te tūpuku hurihuri ko te $I = \frac{1}{2}mr^2$.

He 0.200 m te pūtoro o te wīrā, ā, ko te papatipu o te wīra he 5.00 kg.



He mea urutau nō: http://www.conceptualdynamics.com/files/rbmo/rbmo_rp8.png

Tātaihia te tere koki o te wīra e hiahiatia ana kia anga tonu atu te kāmera ki Papatūānuku.

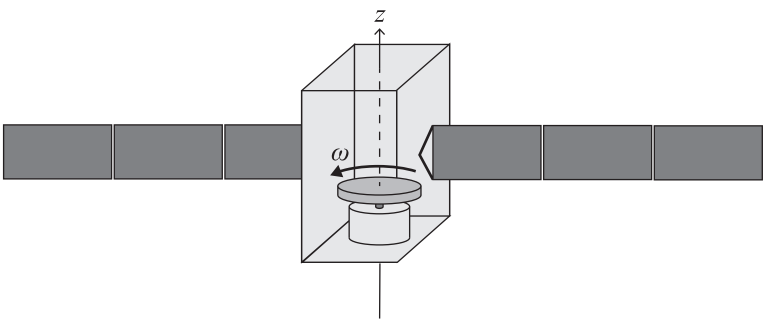
Tuhia ngā whakapae.

MĀ TE KAIMĀKA ANAKE

(d) Instead of using two thrusters to adjust the angular velocity of a satellite, it is often preferable to use a "reaction wheel" system. When the wheel begins to turn in one direction, the satellite will turn in the opposite direction.

The wheel is solid and has rotational inertia given by $I = \frac{1}{2}mr^2$.

The radius of the wheel is 0.200 m and the mass of the wheel is 5.00 kg.



Adapted from: http://www.conceptualdynamics.com/files/rbmo/rbmo_rp8.png

Calculate the angular velocity of the wheel required to keep the camera pointed at the Earth. State any assumptions.

ASSESSOR'S USE ONLY

TŪMAHI TUATORU

Ina hoki ana ngā kaipōkai tuarangi ki Papatūānuku, ka whakaitia e tētahi pūniko i raro i ō rātou tūru te tōpana i te taunga. Ka whakawhitia te pūngao neke o te kaipōkai tuarangi hei pūngao moe pūniko i te wā e whakakōpeketia ana te pūniko. Mēnā he kore noa iho te waku, ka whakauru atu te kaipōkai tuarangi ki te nekehanga hawarite māmā.

(a) Tuhia ngā āhuatanga e hiahiatia ana kia kīia ai he nekehanga hawarite māmā te nekehanga a te kaipōkai tuarangi.

I te wā e tau ana, he 80.0 kg te papatipu tōpū o te kaipōkai tuarangi me te tūru, ā, i uru atu ki tētahi nekehanga hawarite māmā me te teitei o te 0.150 m me tētahi houanga o te 0.940 s.

(b) Whakatauhia:

(i) te aumou pūniko o te pūniko

(ii) te rahinga o te pūngao e puritia ana i roto i te pūniko i te peinga mōrahi.

ASSESSOR'S USE ONLY

QUESTION THREE

When astronauts return to Earth, a spring under their seat reduces the force during the landing. The astronaut's kinetic energy is converted to spring potential energy as the spring is compressed. If friction is negligible, this will set the astronaut into simple harmonic motion.

(a) State the conditions required for the astronaut's motion to be considered simple harmonic motion.

During a landing, an astronaut and seat had a combined mass of 80.0 kg and were set into a simple harmonic motion with an amplitude of 0.150 m and a period of 0.940 s.

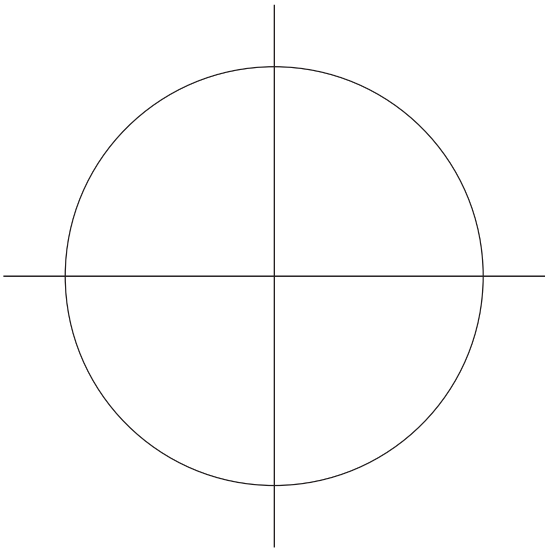
(b) Determine:

(i) the spring constant of the spring

(ii) the amount of energy stored in the spring at maximum displacement.

(c) Mā te whakamahi i tētahi porohita tauira, he tikanga kē atu rānei, whakatauhia te tere o te kaipōkai tuarangi i te wā e 0.100 m ia i runga i te pūwāhi taurite.

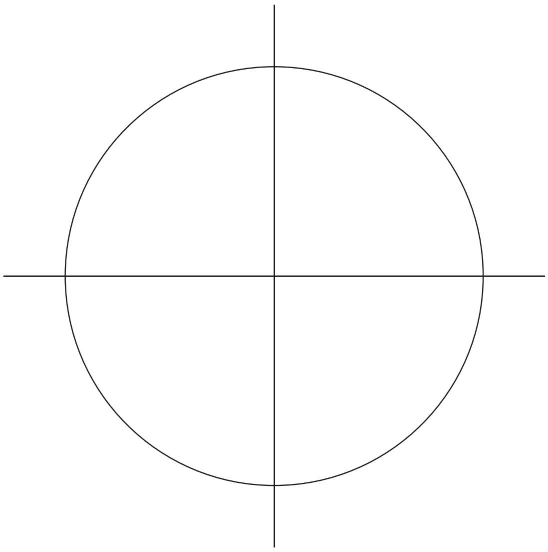
(Ko te whakaaro kāore i whakahekea te nekehanga).



MĀ TE KAIMĀKA ANAKE

(c) Using a reference circle or otherwise, determine the velocity of the astronaut when the astronaut is 0.100 m above the equilibrium position.

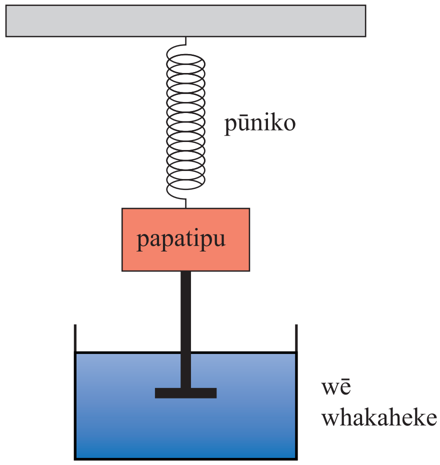
(Assume the motion is un-damped).



ASSESSOR'S USE ONLY

MĀ TE KAIMĀKA ANAKE

(d) Ka tere te whakamutu i te nekehanga o te kaipōkai tuarangi mā tētahi pūnaha whakahekenga kei te pūniko. Ka taea te nekehanga hawarite whakaheke te whakatauira i roto i te taiwhanga mā tētahi papatipu, pūniko, ipurau wai hoki e ai ki te whakaaturanga.



he mea urutau nō: https://brilliant.org/practice/deriving-exponential-decay-from-damping-forces/

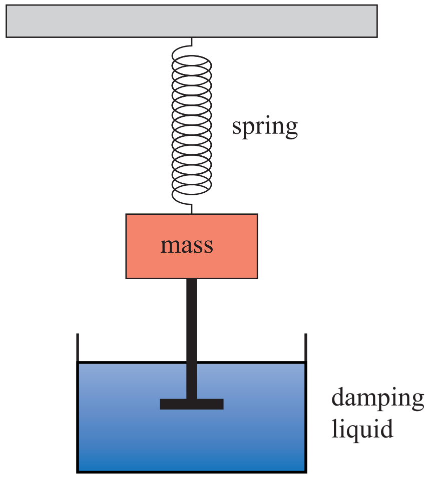
Matapakitia ka pēhea te whai pānga o te whakahekenga ki te teitei me te houanga o te nekehanga hawarite o te papatipu kei te pūniko.

Me whakauru ki tō matapakitanga:

- he whakaahuatanga he aha te tikanga o te whakahekenga
- he whakaahuatanga o te tōpana whakahekenga i roto i te tauira o te taiwhanga, ā, he pēhea te pānga o tēnei ki te nekehanga
- he tātuhinga o tētahi kauwhata o te pūwāhi o te papatipu ki te wā i te tīmatanga tonutanga o te tukutanga o te papatipu mai i te peinga whakararo mōrahi.

ASSESSOR'S USE ONLY

(d) The motion of the astronaut is quickly brought to rest by a damping system on the spring. Damped harmonic motion can be modelled in the laboratory with a mass, spring, and beaker of water as shown.



adapted from: https://brilliant.org/practice/deriving-exponential-decay-from-damping-forces/

Discuss how damping will affect the amplitude and period of the harmonic motion of the mass on the spring.

Your discussion should include:

- a description of what is meant by damping
- a description of the damping force in the laboratory model and how this will impact the motion
- a sketch of a graph of the position of the mass versus time starting at the moment the mass is released from the maximum downward displacement.

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

TAU TŪMAHI

MĀ TE KAIMĀKA ANAKE

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

QUESTION NUMBER

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English translation of the wording on the front cover

Level 3 Physics, 2018

91524 Demonstrate understanding of mechanical systems

2.00 p.m. Tuesday 20 November 2018
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–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 2–19 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.