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3

90521

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Level 3 Physics, 2006

90521 Demonstrate understanding of mechanical systems

Credits: Six
9.30 am Monday 20 November 2006

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 answer ALL the questions in this booklet.

For all numerical answers, full working must be shown, and the answer must be rounded to the correct number of significant figures and given with an SI unit.

For all 'describe' or 'explain' questions, the answer should be written or drawn clearly with all logic fully explained.

Formulae you may find useful are given on page 2.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–10 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.

For Assessor's use only **Achievement Criteria**		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Identify or describe aspects of phenomena, concepts or principles.	Give explanations in terms of phenomena, concepts, principles and / or relationships.	Give explanations that show clear understanding in terms of phenomena, concepts, principles and / or relationships.
Solve straightforward problems.	Solve problems.	Solve complex problems.
Overall Level of Performance (all criteria within a column are met)		

You are advised to spend 55 minutes answering the questions in this booklet.

You may find the following formulae useful.

$F_{net} = ma$	$p = mv$	$\Delta p = F\Delta t$	$\Delta E_P = mg\Delta h$
$W = Fd$	$E_{K(LIN)} = \frac{1}{2}mv^2$		
$d = r\theta$	$v = r\omega$	$a = r\alpha$	$\omega = \dfrac{\Delta\theta}{\Delta t}$
$\alpha = \dfrac{\Delta\omega}{\Delta t}$	$\omega = 2\pi f$	$f = \dfrac{1}{T}$	$E_{K(ROT)} = \frac{1}{2}I\omega^2$
$\omega_f = \omega_i + \alpha t$	$\theta = \dfrac{(\omega_i + \omega_f)}{2}t$	$\omega_f^{\ 2} = \omega_i^{\ 2} + 2\alpha\theta$	$\theta = \omega_i t + \frac{1}{2}\alpha t^2$
$\tau = I\alpha$	$\tau = Fr$	$L = mvr$	$L = I\omega$
$F_g = \dfrac{GMm}{r^2}$	$F_c = \dfrac{mv^2}{r}$		
$F = -ky$	$E_P = \frac{1}{2}ky^2$	$T = 2\pi\sqrt{\dfrac{l}{g}}$	$T = 2\pi\sqrt{\dfrac{m}{k}}$
$y = A\sin\omega t$	$v = A\omega\cos\omega t$	$a = -A\omega^2\sin\omega t$	$a = -\omega^2 y$
$y = A\cos\omega t$	$v = -A\omega\sin\omega t$	$a = -A\omega^2\cos\omega t$	

QUESTION ONE: LUCY ON HER SWING

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Strength of gravity = 9.81 $N\,kg^{-1}$

Little Lucy loves playing on her homemade swing. It is a seat attached to a tree by a rope, and her mum pushes her to make her swing. The swing acts like a simple pendulum, and Lucy's mum pushes her gently so that her swinging motion can always be considered to be simple harmonic motion. Lucy has a mass of 31 kg.

The angular frequency of Lucy's simple harmonic motion is 2.2 $rad\,s^{-1}$.

(a) Using the information given above, calculate the frequency of Lucy's motion.

frequency = ____________

(b) The period of Lucy's simple harmonic motion can be calculated to be 2.9 s. Calculate the length of the rope used to make the swing.

length = ____________

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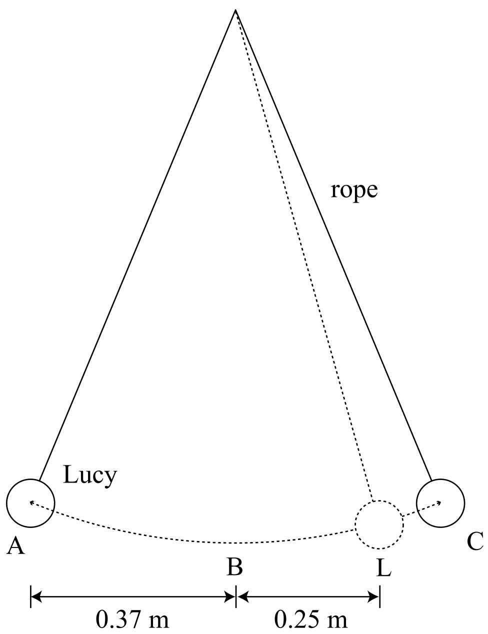
(c) Lucy's mum knows that, as Lucy grows, the length of the rope will have to be shortened. If the length of the rope is **halved**, explain what effect this would have on the period of Lucy's swings.

Lucy's mum stops pushing her, and leaves her to swing freely by herself. Assume the rope is at its original length and that Lucy swings with a constant amplitude of 0.37 m.

(d) Calculate Lucy's maximum acceleration.

maximum acceleration =

The diagram below shows Lucy swinging. At position L, she is travelling towards C, and is 0.12 m from C.



(e) On the diagram above, draw an arrow to show the **direction** of the net force acting on Lucy when she is at position L.

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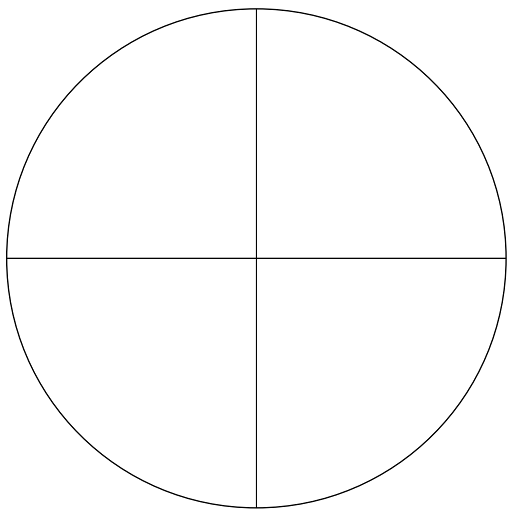
(f) Calculate the size of the net force acting on Lucy at **position L**.

net force =

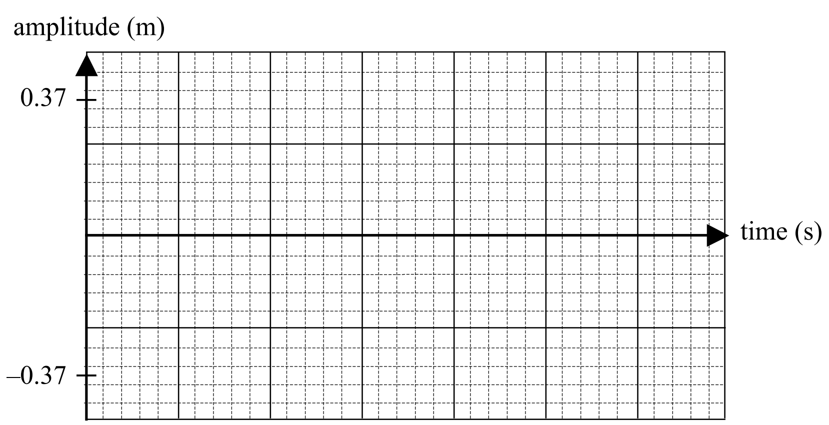
(g) Using the reference circle below, or any other method, calculate the time it would take Lucy to travel from L to C and back to A. Assume the amplitude of her swing remains constant at 0.37 m.



time taken =

In practice there will be a **significant** energy loss due to friction as Lucy continues to swing.

(h) On the axes below, **sketch** a graph of her amplitude against time for **three** oscillations. Values are not required to be marked on either axis.



QUESTION TWO: SPACE – THE FINAL FRONTIER

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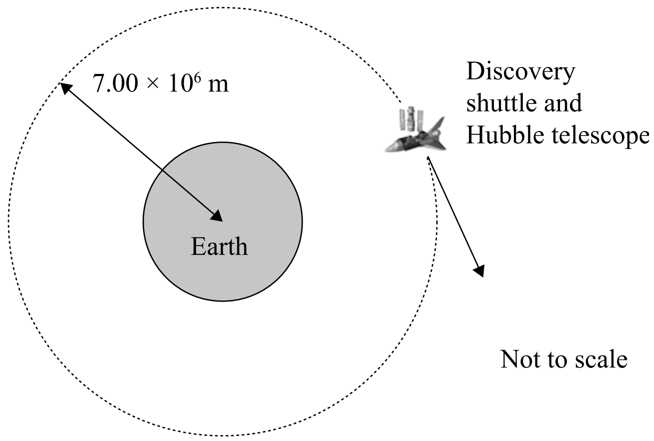
Universal Gravitational Constant = 6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth = 5.98×10^{24} kg.

Part One
The space shuttle Discovery went into a circular orbit of radius 7.00×10^6 m to release the Hubble space telescope, which was attached to the shuttle by a cable. The diagram below shows the shuttle / telescope system orbiting Earth before the shuttle and telescope separated.



(a) Name the force that is keeping the shuttle / telescope system in this circular orbit, and state the direction in which this force is acting.

(b) Calculate the value of the acceleration due to Earth's gravity (strength of Earth's gravitational field) at this height above Earth's surface. Write your answer to an appropriate number of significant figures.

acceleration due to Earth's gravity = ____________

(c) Weight is felt as a reaction force. Explain why an astronaut in the shuttle feels 'weightless' while in orbit about Earth.

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Part Two
Phobos is one of the moons of Mars. It orbits around Mars at a mean radius of 9.38×10^6 m with a period of 2.76×10^4 s.

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www.solarviews.com/eng/phobos.htm

(d) From this information, calculate the mass of Mars.

mass of Mars = ______________

QUESTION THREE: DIVING OFF THE HIGH BOARD

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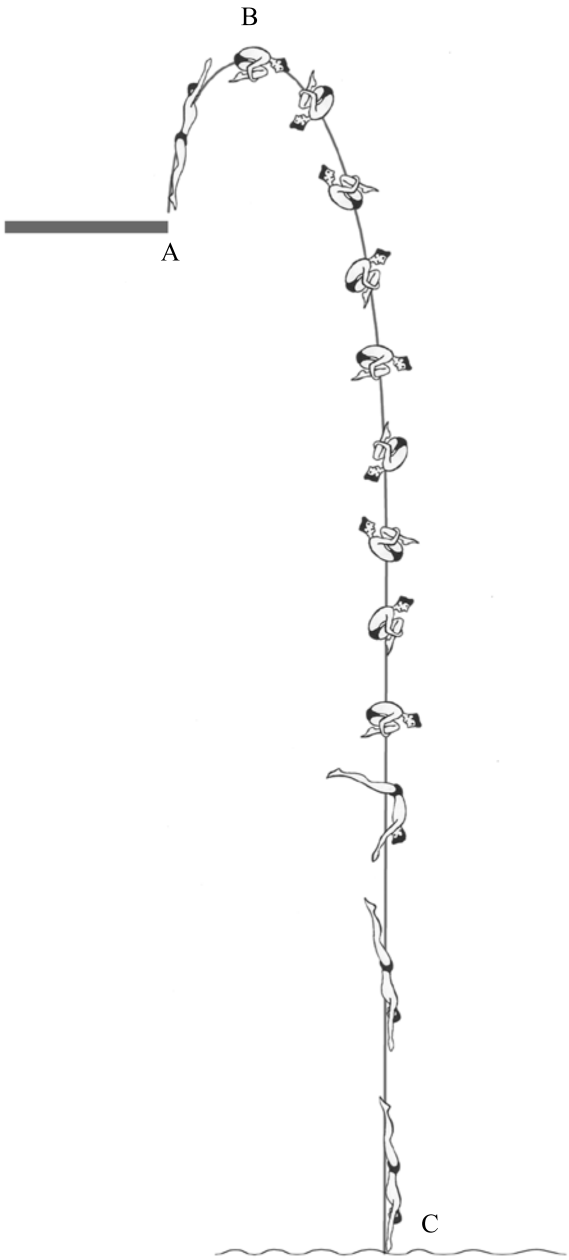
Hopi performs a dive from the high board. After leaving the board at A, he travels up in the air to B, tucking his body into a ball. At the end of his dive, he straightens his body and enters the water head first at C.



When Hopi's body is in the tucked position during the rotations, his rotational inertia is 3.73 kg m^2. Hopi's mass is 76 kg.

(a) When Hopi's body is in the tucked position, his shape can be modelled by a solid sphere of rotational inertia $I = \frac{2}{5}mr^2$. Calculate the radius of the sphere that models Hopi's shape.

radius =

(b) Explain why Hopi must **tuck** his body if the rotations are to be **completed** before he enters the water.

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While his body is in the tucked position, Hopi's angular speed is a constant 9.82 rad s^{-1}. He does two complete rotations in this tucked position.

(c) Show that his angular momentum, while he is rotating in the tucked position, is 36.6 kg $m^2 s^{-1}$.

(d) Calculate the time it takes him to complete the two rotations in the tucked position.

time =

At the end of the tucked rotations, Hopi straightens his body for the entry into the water.

(e) What physics principle applies while Hopi is straightening his body?

It takes Hopi 0.32 s to straighten his body, and during this time his rotational inertia increases by a factor of 5.

(f) Calculate his angular deceleration during this time.

angular deceleration =

Extra paper for continuation of answers if required.
Clearly number the question.

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Question number