PiXL Independence:

Physics – Student Booklet

KS5

Topic – Advanced mechanics and Newtonian gravity

Contents:

PiXL Independence – Level 1
Multiple Choice Questions
A Level Physics – Advanced mechanics and Newtonian gravity

INSTRUCTIONS **Score: /20**

- **Read the question carefully.**
- **Circle the correct letter.**
- **Answer all questions.**

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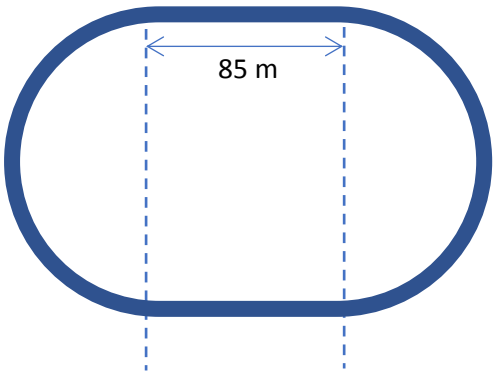
1. Two effects of damping a harmonic oscillator are:
   a. Increase of the amplitude and increase of the resonant frequency
   b. Increase of the amplitude and reduction of the resonant frequency
   c. Reduction of the amplitude and increase of the resonant frequency
   d. Reduction of the amplitude and reduction of the resonant frequency

2. A runner completes a lap of a 400 m track (as shown) in 80 seconds maintaining exactly the same speed throughout. If the straights are 85 m long each, what is the angular velocity ω of the runner around the bends?

   a. 0.14 rad/s
   b. 0.27 rad/s
   c. 0.068 rad/s
   d. 0.20 rad/s



3. An object is launched vertically at 5 km/s from the Earth's surface. How high could it reach above the surface given that air resistance could be ignored? The mass of the Earth is 6.0 x 10^{24} kg. The radius of the Earth is 6400 km.
   a. 1300 km
   b. 1600 km
   c. 3200 km
   d. 8000 km

4. A mass on a spring oscillates with a period of 24.5 seconds per 20 oscillations. The maximum velocity of the mass is 1.8 m/s. What is the amplitude of the oscillations?
   a. 2200 mm
   b. 17.5 mm
   c. 700 mm
   d. 350 mm

5. A displacement vs time graph is shown in figure A for a simple harmonic oscillator. Which of the other graphs show (i) the velocity-time of the oscillator and (ii) the acceleration-time of the oscillator?

Figure A

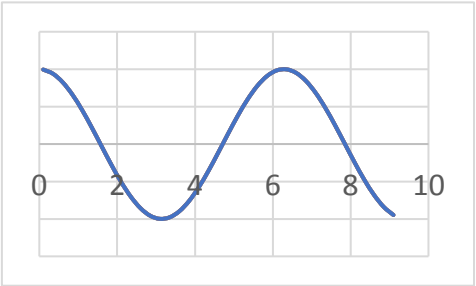


Figure B

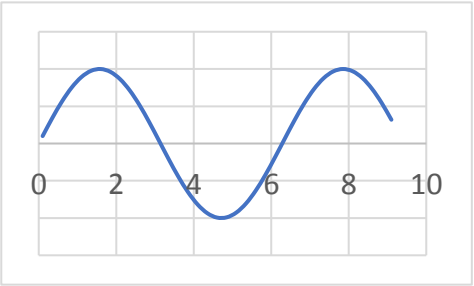


Figure C

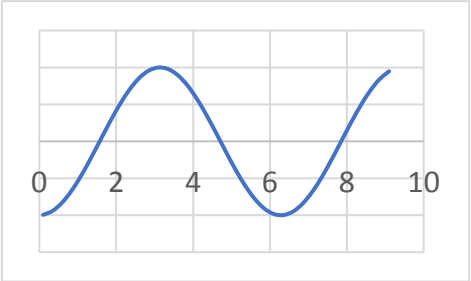
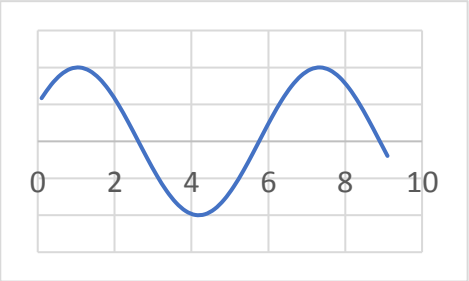


Figure D

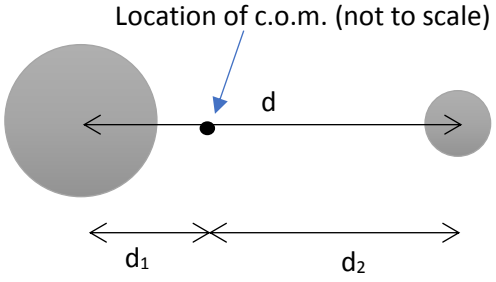


a. Velocity-time (B), acceleration-time (D)
b. Velocity-time (C), acceleration-time (B)
c. Velocity-time (B), acceleration-time (C)
d. Velocity-time (D), acceleration-time (C)

6. Find the radius of geosynchronous orbit given that the mass of the Earth is 6.0×10^{24} kg.

a. 4.2×10^{7} m
b. 6.4×10^{6} m
c. 1.3×10^{7} m
d. 6.4×10^{7} m

7. The mass of the Earth is 6.0×10^{24} kg and of the Moon is 7.4×10^{22} kg. Their centres are separated by d = 3.8×10^{5} km. Determine the location of the centre of mass of these bodies.



a. d_1 = 4600 km from the Earth's centre
b. d_1 = 11000 km from the centre of the Earth
c. $d_1 = 1.9 \times 10^5$ km, exactly half way between the Earth and the Moon
d. d_1 = 6400 km from the Earth's centre

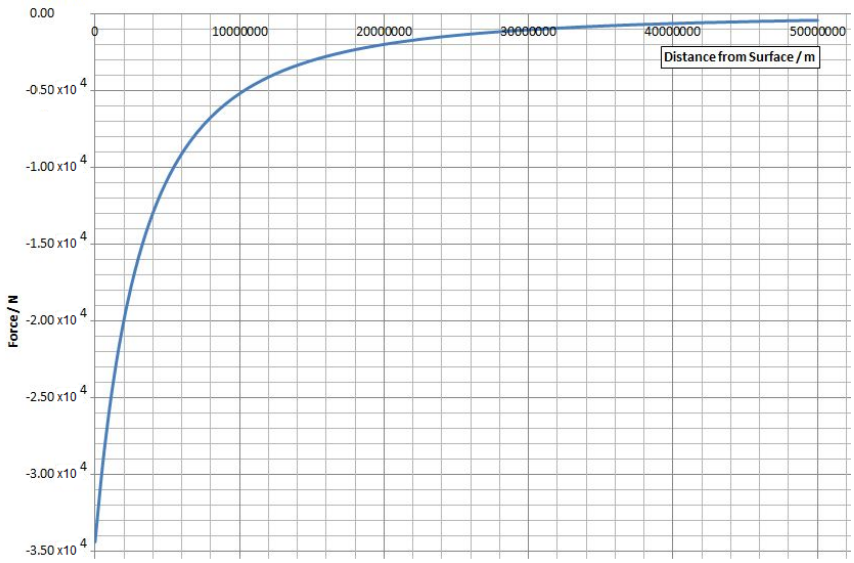
8. Neptune orbits at a distance of 30.1 AU and has a mass 17.1 times that of the Earth. What is the ratio of Neptune's gravitational potential energy about the Sun to that of Earth?
   a. 0.058 : 1
   b. 0.57 : 1
   c. 0.033 :1
   d. 1.67 : 1

9. A rubber bung tied to a piece of string is whirled round in a horizontal plane by a student. The bung has a mass of 40.0 g. The string will snap if a tension of 220 N is applied to it. For a 2.5 meter length of string, what angular frequency can the bung be made to go round before it breaks off?
   a. 7.5 Hz
   b. 47 Hz
   c. 750 Hz
   d. 470 Hz

10. An exoplanet has a mass of 1.41 times that of the Earth but a radius of just 0.8 times as large. What is the gravitational field strength on the surface of this planet? Let the field strength at the surface of the Earth be equal to g.
    a. 1.75 g
    b. 0.90 g
    c. 2.20 g
    d. 1.12 g

11. What is the expression for the escape velocity of an object trying to leave the gravitational influence of an astronomical body of mass M?
    a. $v_e = \sqrt{\frac{2GM}{r}}$
    b. $v_e = \sqrt{\frac{r}{2GM}}$
    c. $v_e = \sqrt{\frac{2Gr}{M}}$
    d. $v_e = 2G\sqrt{\frac{M}{r}}$

12. Estimate the work done against gravity in taking an object from the surface, to 10^7 m from the surface.
    a. 400 GJ
    b. 280 GJ
    c. 140 GJ
    d. 50 GJ



13. The period of a simple harmonic oscillator varies as $T = 2\pi\sqrt{\frac{l}{g}}$ where l is the length of the string and g is the local gravitational field constant. A plot of T^2 on the y-axis vs l on the x-axis would generate a straight line with a gradient of…

    a. g
    b. $(2\pi/g)^2$
    c. $4\pi^2 g$
    d. $4\pi^2/g$

14. A cyclist is moving forwards at a constant u m/s. At the point of contact with the ground, to an observer standing still in the street, this part of the wheel is…

    a. moving forwards at u m/s
    b. moving backwards at u m/s
    c. stationary
    d. unable to say (it depends on the size of the wheel)

15. The definition of SHM can be written as:
    a. The magnitude of the acceleration is proportional to the velocity and always in the opposite direction.
    b. The magnitude of the acceleration is proportional to the displacement (from equilibrium) and always in the opposite direction.
    c. The magnitude of the velocity is proportional to the displacement (from equilibrium) and always in the opposite direction.

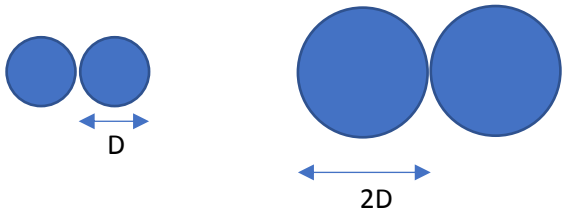
d. The amplitude of the motion is proportional to the period of the motion.

16. Which of these has no effect on the frequency of oscillation of a mass on a spring?
    a. The spring constant of the spring
    b. Whether two springs are used in parallel or series
    c. The mass of the spring
    d. The amplitude of the oscillation

17. What is velocity of Saturn around the Sun? (Saturn orbits at a radius of 1.4 billion kilometers and takes 29.5 Earth years to orbit).
    a. 9.4 km/s
    b. 1.5 km/s
    c. 99.4 km/s
    d. 5.5 km/s

18. The gravitational force experienced between two identical solid tungsten spheres of diameter D that are just touching is 8.5×10^{-7} N. What is the force between two solid tungsten spheres of diameter 2D which are again just in contact?

    a. 1.4×10^{-5} N
    b. 6.8×10^{-6} N
    c. 3.4×10^{-6} N
    d. 8.5×10^{-7} N



19. A pendulum consisting of a mass m on a string of length l is set into circular motion with an angular velocity of ω. During the motion, the string makes an angle of θ degrees with the vertical. Determining tan θ would tell you…

    a. $r\omega^2/g$
    b. $mr\omega^2$
    c. $mr\omega^2/g$
    d. ω/g

20. What is the centripetal acceleration due to the Earth's rotation, felt by someone standing on the Earth's equator? The Earth's radius is 6370 km.

    a. 0.00337 m/s^2
    b. 0.00373 m/s^2
    c. 0.0337 m/s^2
    d. 0.0373 m/s^2

PiXL Independence – Level 2
5 questions, 5 sentences, 5 words
A Level Physics – Fields

INSTRUCTIONS

- **For each statement, use either the suggested website or your own text book to write a 5-point summary. In examinations, answers frequently require more than 1 key word for the mark so aim to include a few key words.**
- **It is important to stick to 5 sentences. It is the process of selecting the most relevant information and summarizing it, that will help you remember it.**
- **Write concisely and do not elaborate unnecessarily, it is harder to remember and revise facts from a big long paragraph.**
- **Finally, identify 5 key words that you may have difficulty remembering and include a brief definition. You might like to include a clip art style picture to help you remember it.**

Example: Base and derived units

QUESTION:	**How do you determine the mass of a small object using centripetal motion?**
Sources:	**Website** **1.** https://www.youtube.com/watch?v=amVeCB7sJQI **2.** www.schoolphysics.co.uk/age14-16/.../Circular%20motion/.../Whirling_bung.doc **3.**

1. **Attach weights to a string, pass string through a tube and attach unknown mass to other end of string.**
2. **Spin the string around with the weight of the known mass (hanging off the bottom) matched by the centripetal force acting to keep the rubber bung in "orbit" at a fixed radius via the tension in the string.**
3. **$T = W = Mg$ and $T = F_c = m\omega^2 r$ so $Mg = m\omega^2 r$**
4. **Determine ω from the period by counting (20 periods) and using $\tau = 2\pi/\omega$. Repeat for various Mg (i.e. known masses added keeping the length the same.**
5. **Now have $Mg = mr(2\pi/\tau)^2$. Plot τ^2 vs $1/Mg$ to get $4\pi^2 mr$ as gradient to thus determine m.**

$\tau = 2\pi/\omega$	**$F_c = m\omega^2 r$**	**Tension provides centripetal force**	**Reducing uncertainties – count 20 times.**	**Balancing forces**

QUESTION 1:	**Explain how to calculate orbital periods and velocities of man-made satellite.**
Sources:	**Website** 1. https://www.youtube.com/watch?v=nxD7koHdQhM 2. https://www.youtube.com/watch?v=HyuH1apnPmU 3. http://www.a-levelphysicstutor.com/field-gravit-2.php

QUESTION 2:	**Describe difference and similarities between electric and gravitational fields.**
Sources:	**Website** **1.** https://youtu.be/KfZIjNY7Cp0 **2.** https://www.s-cool.co.uk/a-level/physics/a-comparison-electric-and-gravitational-fields/revise-it/a-comparison-electric-and

QUESTION 3:	**What are the effects of dampening on resonance curves.**
Sources:	**Website** 1. https://www.youtube.com/watch?v=y0YFw9ZzSyM 2. https://www.youtube.com/watch?v=uP3J_Ad2Zhw 3. https://www.youtube.com/watch?v=urYWaHfel6g 4. http://physicsnet.co.uk/a-level-physics-as-a2/further-mechanics/forced-vibrations-resonance/ (+ videos within)

QUESTION 4:	**Artificial gravity for space missions. How might we achieve this?**
Sources:	**Website –** 1. https://www.youtube.com/watch?v=im-JM0f_J7s 2. http://www.school-for-champions.com/science/gravity_artificial_equations.htm#.WicRK0176yo 3. http://www.digipac.ca/chemical/mtom/contents/chapter1/rotation.htm

QUESTION 5:	**The ISS is in low Earth orbit, well inside Earth's gravitational field. Why are they "weightless"?**
Sources:	**Website** 1. https://www.universetoday.com/95308/why-are-astronauts-weightless-in-space/ 2. https://www.youtube.com/watch?v=iQOHRKKNNLQ

PiXL Independence – Level 3
Physics in The News
A Level Physics – Advanced mechanics and Newtonian gravity

Fake news

Sensationalized news stories have been around for some time but, with the mass growth of social media, the problem seems to have grown in recent years. At the very least, the US Presidential election has certainly highlighted the impact that misleading information can have. www.tiny.cc/fakenews2

At home, the Brexit vote also suffered from the circulation of misleading news stories www.tiny.cc/fakenews3

Therefore, the ability to identify real information, track it back to the source article and make your own judgement is a very important skill. This activity will help you develop that skill.

News article

http://metro.co.uk/2016/07/19/here-are-10-proofs-that-the-earth-is-actually-flat-not-round-6016710/

http://www.bbc.co.uk/news/av/41973119/why-do-people-still-think-the-earth-is-flat

Research

https://www.scientificamerican.com/article/earth-is-not-round/

http://practicalphysics.org/greek-evidence-earths-shape-and-spin.html

http://www.physlink.com/education/askexperts/ae535.cfm

Videos

https://www.youtube.com/watch?v=VNqNnUJVcVs

Task:
You need to produce 1-page summarizing the arguments for and against the flat Earth theory.Conclude with your opinion on the matter.

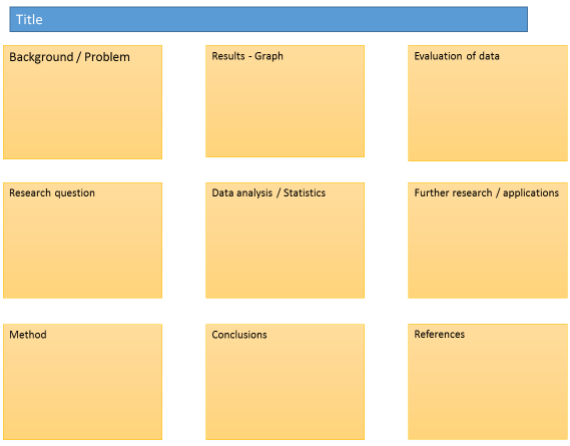
Essay section	Activity
Introduction	Why do some people believe it is flat?
Describe	What evidence exists to prove that it is (close to) spherical?
Explore	Arguments and counterarguments, sticking to purely scientific reasoning.
Evaluate	Evaluate the pros and cons of each side of the argument before your conclusion.

PiXL Independence – Level 4
Scientific Posters
A Level Physics – Advanced mechanics and Newtonian gravity

Scientific Posters - Scientists communicate research findings in three main ways. Primarily, they write journal articles much like an experiment write up. These are very concise, appraise the current literature on the problem and present findings. Scientists then share findings at conferences through talks and scientific posters. During a science degree, you would practise all three of these skills.

Scientific posters are a fine balance between being graphically interesting and attracting attention and sharing just the right amount of text to convey a detailed scientific message. They are more detailed than a talk and less detailed than a paper.
Use this information to help structure your poster – www.tiny.cc/posterskills
More detailed guidance is available at : www.tiny.cc/posterskills2

Creating your poster
It is easiest to create a poster in PowerPoint, however you need to add custom text boxes rather than using the standard templates.



Posters need to be eye catching, but readable from a distance. If you use PowerPoint, start with a 4:3 slide (for easier printing, it can then be printed on A3) and use a 14-16 pt font. The first box could be larger to draw people in. You can use a background image, but pick a simple one that is of high quality. Select 'text box fill' and select 'change the transparency' to maintain the contrast and partially show the picture.
You can experiment with different layouts and you should include images. Avoid a chaotic layout, posters are read from top left column downwards.
Remember to include the authors and references.
Finally, look at the examples given on the University of Texas website which also offers an evaluation of each www.tinyurl.com/postereg

Limits to human tolerances and circular motion

Background
Fighter aircraft and display aircraft are reaching a limit; the twists and turns they perform during advanced maneuvers places massive centripetal acceleration forces (g-forces) on the pilot which can ultimately lead to blacking out and loss of aircraft control.

In this you will learn about centrifuges. The last link shows a different application of centrifuges used commonly in science.

Source articles:

https://www.youtube.com/watch?v=79rYbkTi4fs

https://www.youtube.com/watch?v=VBYpAtWW1UU

https://www.redbull.com/gb-en/how-the-red-bull-air-race-pilots-keep-conscious-at-10g

https://www.youtube.com/watch?v=4ZQdWmkzNho

https://www.youtube.com/watch?v=KEXWd3_fM94

Use other sources as necessary.

Task:
Produce a scientific poster on the effects of tight cornering in (jet) flight, the effects on the body, what can be done to mitigate this somewhat. Optionally, add a small box on "other application" of this centrifugal action.

Recall	Circular motion physics.
Describe	What forces act on the human body during high acceleration turning and the results of these forces.
Compare	Linear with circular motion.
Evaluate	The usages of centripetal forces, positive and negative.

PiXL Independence – Level 5
Video summaries
A-level Physics – Advanced mechanics and Newtonian gravity

Cornell Notes

At A level and University, you will make large amounts of notes, but those notes are only of use if you record them in a sensible way. One system for recording notes is known as the Cornell notes system. This method encourages you to select relevant information, rather than trying to write a transcript of everything said. More importantly, it forces you to spend a few minutes reviewing what you have written, which has been scientifically proven to aid learning and memory retention.
The ideal is to write everything on one page, but some students may prefer to type and others will to handwrite their notes. Whichever option you use, remember the aim is to summarise and condense the content with a focus on the objectives that you are trying to learn and understand.

There are three main sections to the Cornell notes

1. **Cue/ Objectives** – This can be done before or after the lecture. You may have been provided with the objectives or you may need to decide what they were or you may want to make the link to your learning if this is an additional task or lecture you are viewing, such as this video.
2. **Notes** – In this space you record concisely, simply the things you are LESS likely remember - **The NEW knowledge.**
3. **Summary** – The most important step that is carried out after the lecture or video. This helps to reinforce learning.

Background

Lagrange points refer to points in near Earth space where objects, notably man-made satellites, will stay in a fixed position relative to the Earth. They are of upmost importance to physics and the space industry. You will learn why and, conceptually, how to determine where they are located. If you choose to go deeper, the maths can get beyond a-level quite quickly, but the idea of how forces must be balanced and how this affects the orbital period of satellites that are not the same distance to the Sun as the Earth can be understood at least qualitatively. Some simplified maths can be found in the second source article.

Source articles: https://www.space.com/30302-lagrange-points.html
https://ibmathsresources.com/tag/lagrange-points/

Video 1 - https://www.youtube.com/watch?v=mxpVbU5FH0s
Video 2 - https://www.youtube.com/watch?v=foyJzvpeaBE
Alternative - https://www.youtube.com/watch?v=wx16npnSPUo

Visualised - https://www.youtube.com/watch?v=z52WWLE8bBo

Task:
You need to produce a set of Cornell notes for the videos given above.
Use the following objective to guide your note taking, this links to your learning.

Objectives What are the main learning outcomes that have been shared with you? This will help guide you to taking the RIGHT notes during the video.	Title Date Sketch down note and key words Do not write in full sentences whilst you listen, put quick sketches, single words, mind maps, short hand etc. To help train you for university, try not to pause the video because you could not pause a live lecture (However, a lecture may give more natural pauses for you to catch up).

Summary (after the video)
What are your main points of learning from this video.
This is your chance to make sense of your notes.
Make clear connections to the things you need to know

Objectives:	**Title:** **Date:**
Summary:	

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