ASSESSMENT TASK 2-10

HSC PHYSICS

THEORY TASK

Marking Guidelines

Exam Question	Marks	K+U or A+PS	Syllabus Mapping	Outcome Mapping
SECTION I				
PART A				
1	1	K+U	9.2.1.1.3	H7, H12, H13
2	1	K+U	9.2.2.1.3	H2, H7, H9
3	1	K+U	9.2.3.1.4	H4, H7, H9
4	1	A+PS	9.2.1.2.3	H6, H9, H12, H13
5	1	A+PS	9.2.3.2.2	H6, H9, H12, H13
PART B				
6	3	K+U	9.2.2.1.7	H1, H2, H6
7	5	A+PS	9.2.2.2.1	H6, H11, H13
8a	2	K+U	9.2.2.1.10	H6, H12, H13
8b	3	K+U	9.2.2.2.11	H6, H7, H14
8c	2	A+PS	9.2.2.2.5	H6, H12, H13
SECTION II				
9a	2	A+PS	9.6.1.2.1, 9.6.1.2.5	H8, H12, H13
9b	3	K+U	9.6.2.1.2	H8, H9, H10
9c	3	A+PS	9.6.1.2.4	H7, H8
9d	7	K+U	9.6.4.2.4	H4, H5, H8, H10
9e (i)	2	K+U	9.6.4.1.1, 9.6.4.1.2	H1, H9, H10
9e (ii)	3	K+U	9.6.4.1.5, 9.6.4.1.6	H7-H10, H14

This represents 26 marks of K+U and 14 marks of A+PS. This is in approximate keeping with the assessment schedule distributed to all students at the start of the year, i.e.: 2:1 ratio.

*This represents 13 marks of calculations, i.e. 32.5% of this theory task is based on calculations

ASSESSMENT TASK 2-10
HSC PHYSICS
THEORY TASK

Marking Guidelines

SECTION I PART A

	1	2	3	4	5
	C	D	B	B	C
% correct	36	79	64	100	50

Solutions to calculations

1 $$E_P = -\frac{Gm_r m_E}{d} = -\frac{(6.67\times10^{-11})(2.00)(6.0\times10^{24})}{6380\times10^3} = -12545454.55 = -1.3\times10^8 \text{ J}$$

4 $$m_{Earth} = \frac{W}{g} = \frac{736}{9.81} = 75.025....\text{kg}$$

$$W_{Mars} = mg = 75.025...\times3.73 = 279.845... = 280\text{ N}$$

5 $$F_C = F_G = \frac{Gm_{HST}m_E}{d^2} = \frac{(6.6.7\times10^{-11})(11000)(6.0\times10^{24})}{((600\times10^3)+(6380\times10^3))^2} = 90356.40... = 9.0\times10^4\text{ N}$$

SECTION I PART B

Question 6 (3 marks)

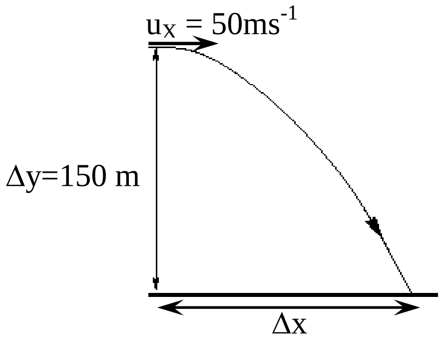
Response includes the following points: • relates the Law of Conservation of Momentum to the equal and opposite nature of the two components of final momentum, ie. momentum of the rocket and momentum of the exhaust • obtains an expression for the velocity of the rocket during its launch • relates the nature of a steady burn to the changing velocity of the rocket during its launch Response is clear and succinct (ie. subscripts are clear)	3
Response includes most of the above points	2
Response includes one of the above points	1

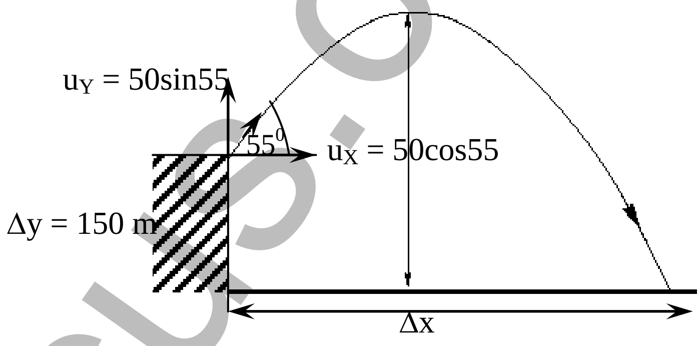
Sample answer:
The Law of Conservation of Momentum states that the total momentum of an isolated system remains constant, ie. $p_f = p_i$ (if no external forces). Since the total momentum of a rocket is zero immediately before a launch, it follows that the final momentum ($p_f = p_{rocket} + p_{exhaust}$) also equals zero. This means that after the launch, the momentum of the rocket is equal in size but opposite in direction to the momentum of the exhaust, ie. $p_{rocket} = - p_{exhaust}$. Since momentum equals the product of mass and velocity, we can write this as $m_{rocket}v_{rocket} = - m_{exhaust}v_{exhaust}$.
Rearranging this equation gives us $v_{rocket} = - m_{exhaust}v_{exhaust}/m_{rocket}$. If the fuel is being burnt at a constant rate, we would expect the velocity of the exhaust to stay constant, the mass of the rocket (made up of fuel that is being burnt) to decrease and the mass of the exhaust to increase,
ie. $m_{exhaust}\uparrow$, $m_{rocket}\downarrow$, and $v_{exhaust}$ = constant. This means that the velocity of the rocket increases at an increasing rate during its launch.

Question 7 (5 marks)

Response includes: • correct calculation of the range of projectile launched horizontally • correct calculation of the range of projectile launched at an angle • appropriate statement contrasting the two ranges	5
• correctly calculates the time of flight and/or range of projectile launched horizontally AND/OR • the time of flight and/or range of projectile launched at an angle AND/OR • makes an appropriate statement contrasting the two ranges	3-4
• some attempt is made to calculate the time/s of flight and/or range/s of the projectiles	1-2

Sample answer:





$u_Y = 0\ ms^{-1}$ $\quad u_x = 50\ ms^{-1}$
$\Delta y = 100$ m ↓ $\quad \Delta x = ?$
$a_y = 9.8\ ms^{-2}$ ↓ $\quad t$ from vertical info.
$t = ?$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

$$150 = 0 + \frac{1}{2}(9.8)t^2$$

$$t = 5.5328.....\text{s}$$

$$\therefore \Delta x = u_x t$$
$$= 50 \times 5.5328....$$
$$= 276.641....\text{m}$$
$$\approx 2.8 \times 10^2 \text{ m}$$

$u_Y = 50\sin55°\ ms^{-1}$ ↑ = $-50\sin55°\ ms^{-1}$ ↓
$\Delta y = 150$ m ↓ $\quad \underline{u_X} = 50\cos55°\ ms^{-1}$
$a_y = -9.8\ ms^{-2}$ ↓ $\quad \Delta x = ?$
$t = ?$ $\quad t$ from vertical info.

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

$$150 = -50\sin 55° t + \frac{1}{2} \times 9.8 t^2$$

$$4.9t^2 - 50\sin 55° t - 150 = 0$$

$$t = \frac{50\sin 55° \pm \sqrt{(50\sin 55°)^2 - 4 \times 4.9 \times -150}}{2 \times 4.9}$$

$$= 11.1132......\text{s } (t > 0)$$

$$\therefore \Delta x = u_x t$$
$$= 50\cos 55° \times 11.1132.....$$
$$= 318.715.....\text{m}$$
$$\approx 3.2 \times 10^2 \text{ m}$$

The range of the canon ball launched horizontally is less than that of the canon ball launched at an angle.

Question 8a (3 marks)

substitutes into correct equation to calculate the orbital speed	2
attempts to calculate the orbital speed using the correct formula OR correctly converts the time into seconds	1

Sample answer:
t = 7 hours 39 min = (7 x 3600) + (39 x 60) = 27540 s
r = 9.5 x 10^6 m

$$v = \frac{2\pi r}{T} = \frac{2\pi(9.5\times10^6)}{27540} = 2167.402... = 2.2\times10^3 \text{ ms}^{-1}$$

Question 8b (3 marks)

Response includes reference to the following points: • relates atmospheric thickness at lower altitudes to greater air resistance on satellites in LEO • relates air resistance on satellite to a decrease in its orbital speed (or heat and kinetic energy) • relates a decrease in orbital speed (or kinetic energy) to a decrease in altitude OR • relates cause and effect to two different issues such as air resistance and tracking stations	3
Response includes most of the above points	2
Response includes one of the above points	1

Sample answer:
Satellites in low Earth orbits are affected by air resistance because the atmosphere is thicker near the Earth's surface due to gravity. The air resistance causes the satellites orbital speed to decrease. This decrease in speed causes the satellite to decrease in altitude. (As the satellite drops in altitude the atmosphere is even thicker so provides greater air resistance on the satellite slowing it down even further. The heating effects associated with such air resistance can cause a satellite to eventually burn up.

Question 8c (2 marks)

correctly calculates the orbital radius	2
attempts to calculate the orbital radius	1

Sample answer:
T = 24 hours = 24 x 3600 = 86400 s
M = 6.0 x 10^{24} kg

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$\frac{r^3}{86400^2} = \frac{6.67\times10^{-11}\times6.0\times10^{24}}{4\pi^2}$$

$$r = 42297523.87.. \approx 4.2\times10^7 \text{ m}$$

Section II

Question 9(a) (2 marks)

correctly calculates the velocity of ultrasound in the kidney to 3 sig. figs	2
attempts to calculate the velocity of ultrasound in the kidney	1

Sample answer:

Z = 1.62 x 10^6 kg m^{-2} s^{-1}
ρ = 1.04 x 10^3 kg m^{-3}

$$Z = \rho v$$
$$1.62\times10^6 = 1.04\times10^3 v$$
v = 1557.692…≈ 1.56 x 10^3 ms^{-1}

Question 9(b) (3 marks)

Response includes: • at least three comparisons • AND at least one significant similarity and one significant difference	3
Response includes some similarities AND/OR differences	1-2

Sample answer:

	Soft X-rays	**Hard X-rays**
Similarities	Both are a form of electromagnetic radiation (and hence travel at c in a vacuum).	
	Both are produced by rapidly decelerating high speed electrons.	
Differences	have a longer wavelength (λ > 1 nm) and lower frequency	have a shorter wavelength (λ < 0.01 nm) and higher frequency
	less penetrating (less energetic) – will not penetrate the body and can burn the skin	more penetrating (more energetic) – will penetrate the body but can absorbed by material such as bone.
	produced by lower accelerating potential difference across cathode and anode	produced by higher accelerating potential difference across cathode and anode
	not used in medical imaging (filtered out if possible)	used in medical imaging

Question 9(c) (3 marks)

Response includes: • at least three differences in the use of x-rays and ultrasound for measuring bone density • reference to the difference/s in the way in which each technique is produced • reference to the difference in the type of results obtained (or the purpose of the test)	3
Response includes some differences between X-rays and ultrasound	1-2

Sample answer:

X-rays (DEXA)	**Ultrasound**
Uses low energy X-rays	Uses high frequency sound waves
Involves measurement of lumbar spine and left hip	Involves measurement across the heel of the foot
Provides quantitative information (more accurate)	Provides qualitative information (screening only)
Need to see a radiographer for test	Available through mobile units at pharmacies
More expensive	Less expensive
Exposure to ionising radiation	No risk to patient of ionising radiation.

Question 9(d) (7 marks)

Response includes: • an outline of each of the processes of CAT and PET and how they relate to cancer detection • at least one relevant advantage and one disadvantage of each type of scan • at least two comparisons that relate specifically to the detection of cancer • appropriate judgement as to which is most suitable Response is clear and concise	7
Response includes most of the above points	5-6
Response includes some of the above points	3-4
Some attempt is made to distinguish CAT scans from PET scans	1-2

Sample answer:
Both PET scans and CT scans may be used detect the occurrence of cancer.

PET scanners can detect the functioning of different parts of the body. They rely on the introduction of a radiopharmaceutical that contains a positron emitter. Once inside the body, the radiopharmaceutical accumulates in the region of interest and annihilates with local electrons to form pairs of gamma rays that are detected by a ring of detectors around the body. A computer is used to analyse the attenuation of the gamma rays and their difference in time of the pairs to reach the detectors allowing an image to be produced. The parts of the body that are diseased tend to be metabolically more or less active. Cancer cells are generally more metabolically active than normal cells and show up as hot spots on the scan. Although the anatomical images produced are not great, they give detailed functioning of diseased parts of the body. PET scans require the use of a radioactive isotope. The production of this radioisotope produces radioactive waste that needs to be disposed of. At present the waste is buried in the ocean. This may lead to radiation leaching into the environment causing damage to ecosystems as well as local people. Any exposure to ionising radiation can itself be carcinogenic.

A CAT scan produces very good quality anatomical/structural views of the body. They are formed by X-rays being directed at many angles around the body and detected after they have passed through the body. A computer is used to analysed the attenuation of the X-rays from each of the angles to allow a 2D cross-sectional image to be formed from each slice of the body. A 3D image can be produced from many 'slices' of the body, and this image can be viewed from many different orientations. A cancerous tumour is able to be detected when it is large enough to have displaced other tissue allowing a sufficient difference in the attenuation of the X-rays around this region. CAT scans require exposure to ionising X-rays (even though patients are given a low dose) and so are potentially carcinogenic. CAT scans may not be able to detect very small tumours because they do not appear sufficiently different on this structural image.

Both PET and CAT can be used in the detection of cancer. PET scans enable the early detection of cancerous areas and the spread of cancer whereas CAT scans allow the precise position to be determined. Although both can be used, it would be even better to use a combined CAT/PET machine.

FYI
PET scans differ from conventional CAT because this newer test is better able to detect much smaller, microscopic amounts of cancer cells that have been left over after treatment and to verify that a suspicious mass is truly cancer. CAT, on the other hand, is only able to detect larger masses, and only a surgical procedure, or biopsy, can verify that the CAT-detected mass is cancer. A PET scan can verify that even small masses are cancerous because the technique uses a type of sugar, or glucose, that glows. Cancer cells ingest larger amounts of glucose than normal cells, so they glow "hotter" than normal cells. So while CAT can identify suspicious masses based on their size, PET scans can identify masses that are cancerous based on their behavior. PET scans can be used in place of biopsy in some patients suspected of having lung cancer, and helps to guide treatment. "PET allows us to see the metabolism of a tumor," Conti said. "From that we can infer whether it's benign or malignant, if it has spread or whether treatment has been successful. Note: Medicare has agreed to reimburse for PET scans to stage and diagnose lung cancer. The main concern we have is that this test uses radiation; however, the radiation exposure involved is less than that received from many CT Scan Procedures. http://www.west.net/~cure/tests_to_detect_cancer.htm

Combined PET/CT scanning joins two imaging tests, CT and positron emission tomography (PET), into one procedure. A PET scan creates colored pictures of chemical changes (metabolic activity) in tissues. Because cancerous tumors usually are more active than normal tissue, they appear different on a PET scan. Combining CT with PET scanning may provide a more complete picture of a tumor's location and growth or spread than either test alone. Researchers hope that the combined procedure will improve health care professionals' ability to diagnose cancer, determine how far it has spread, and follow patients' responses to treatment. The combined PET/CT scan may also reduce the number of additional imaging tests and other procedures a patient needs. However, this new technology is currently available only at some facilities. http://www.cancer.gov/cancertopics/factsheet/Detection/CT

Question 9(e) (i) (2 marks)

Response includes reference to the following points: • protons and neutrons occupy energy levels in nucleus either spin-up or spin-down • protons pair with protons and neutrons with neutrons • net spin calculated from the unpaired protons and/or neutrons	2
Response relates net spin to unpaired nucleons	1

Sample answer:
Nucleons (protons and neutrons) have allowed energy levels within the nucleus. Nucleons will fill these energy levels by pairing themselves with spin-up (½) and spin-down (-½).However, neutrons will pair only with neutrons and protons with protons. Net spin is the result of unpaired protons and/or neutrons.

- If all protons are paired and all neutrons are paired, net spin = 0.
- If there are unpaired protons OR unpaired neutrons, net spin = 1/2, 3/2, …
- If there are unpaired protons AND unpaired neutrons, net spin = 1,2,..

Question 9(e) (ii) (3 marks)

Response includes reference to the following points: • description of the terms: precession, Larmor frequency, net spins and H-nuclei (protons) • outline of the processes of resonance and relaxation • relates the terms to magnetic resonance imaging Response is clear and concise	3
Response includes reference to some of the above points	1 - 2

Sample answer:
When a patient is placed inside a strong magnetic field, all nuclei with net spin in their body precess at what is known as their Larmor frequency which depends on both their magnetic moment and the strength of the magnetic field. They precess (ie. their axis of magnetic spin traces out a circle around a magnetic field line) out of phase and with slightly more parallel than anti-parallel to the magnetic field lines. When radio waves of same frequency as the Larmor for H-nuclei (protons) are pulsed into the patient, they cause the protons to resonate and their energy is absorbed causing them to precess in phase and some of them to flip to the higher energy state (ie. precess anti-parallel to the magnetic field). After the RF pulse, the protons relax and the energy that they absorbed is radiated as the free induction decay (FID) signal. This signal is detected by coils outside the body and analysed by a computer to produce an MR image.