Physics

2014 Senior External Examination: Assessment report

Statistics

Year	Number of candidates	Level of achievement				
		VHA	HA	SA	LA	VLA
2014	14	0	5	4	4	1
2013	27	3	7	7	7	3
2012	26	3	7	11	4	1
2011	26	4	6	10	6	0
2010	23	3	3	6	9	2

General comments

Paper One Part A assessed *Knowledge of subject matter* and consisted of 15 multiple-choice questions and 10 short-response questions covering all syllabus topics. Candidates were required to respond to all questions; marks allocated were in proportion to syllabus topic weightings. Paper One Part B assessed *Scientific processes* and consisted of six questions assessed by criteria specific to each question. Candidates were required to respond to all six questions.

Paper Two assessed *Complex reasoning processes* and consisted of six questions assessed by specific criteria. Candidates were required to respond to all six questions.

Paper One

Part A — Knowledge of subject matter

Multiple-choice questions

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Correct response	C	C	B	C	A	D	D	C	D	C	A	B	A	B	B

Short-response questions

This part of the examination required candidates to demonstrate their knowledge and ability regarding simple application of the syllabus topics. Many responses indicated that candidates had attempted to learn information but did not have a full understanding of the underlying principles and processes.

Question 1

Most candidates clearly understood the notion of significant figures and could apply it in the given situation.

Question 2

Candidates generally converted percentage errors into absolute errors with few problems.

Question 3

This problem was generally understood by candidates, although there was some confusion using the equations to properly calculate the result in Question 3a. Some more work with equations of impulse would have been useful. The concept of work done as equal to the KE was well understood.

Question 4

This was a reasonably straightforward application of theory and candidates did not experience difficulty if they understood what the question was asking.

Question 5

The diagram did not seem to confuse candidates, although some candidates did not complete the nodal lines along the whole length or left some significant areas out. Explicit practise in this and in the different ways in which diagrams could represent the point sources (e.g. dotted, solid or no lines) would have helped.

Question 6

Most candidates were able to use the appropriate formula, although some paid little attention to the units used.

Question 7

The simple application of formula was either generally done well or not at all. Most candidates did well. While this is a typical examination question, some candidates may have been confused by the addition of the mass of the particle.

Question 8

Candidates generally successfully completed with this problem. As this type of question has appeared in a previous examination, candidates seemed better prepared this year. However, the need to read the information from an actual appliance label, with its range of values instead of a fixed one, showed some candidates were only comfortable with direct substitution into the formula rather than understanding the concept.

Question 9

Candidates who recognised the question type had little problem in using the formula correctly.

Question 10

This type of question appeared in last year’s examination and most 2014 candidates handled the task well. Errors included not successfully managing the numbers of proton and neutrons and not correctly identifying the resultant nuclei. There was also some variety in how the term ‘explain your reasoning’ was interpreted, but most candidates did so adequately using the concept of changes in particular quantities.

Part B — Scientific processes

Question 1

Candidates generally interpreted the graph correctly, and they were able to identify the areas as requested. Some candidates also attempted to justify this choice, although they had not been asked to do so.

Question 2

Despite the standard nature of the required response, not all candidates completed this question successfully. Some marked the graph in unusual ways in Question 2a, suggesting they did not properly understand how to read a displacement–time graph to provide the information the question was asking for. Most candidates understood that the required line for total energy was flat in Question 2b. Few candidates successfully completed Question 2c, with most failing to note the exponential decay over time or to maintain the wavelength to show a constant period.

Question 3

Some candidates were unsuccessful in this question. Given it was a square graph and that the superposition was therefore straightforward, it indicates that some candidates need more practice in responding to this type of problem. As candidates had to first work out the new positions of the wave, this extra step might provide a focus for question rehearsal.

Question 4

Candidates typically responded satisfactorily to this question and, considering it is a standard plot of data, this was expected. Some candidates struggled with the correct scaling of the graph, sometimes halving the time instead of the count, showing perhaps a lack of familiarity with the task.

Question 5

Candidates clearly understood the nature of the task. Some, however, struggled to coherently and logically lay out a numbered sequence of experimental steps. This is a skill that could be practised.

Question 6

Candidates were quite effective at identifying the required elements in the diagram, although some struggled again to give a clear and coherent explanation for Question 6b. Candidates who understood the nature of proportionality had little difficulty in justifying their response in Question 6c, either by graph or ratio.

Paper Two — Complex reasoning processes

Question 1

Candidates generally approached this question with familiarity. A few candidates calculated some standard quantities, but not always with the end in sight. Some candidates failed to make the link between force down the plane, acceleration and overall time.

Question 2

This was a standard question type and most candidates handled it well.

Question 3

This question, while short, required careful reading. The step between the spring constant calculation and maximum height proved difficult for some candidates.

Question 4

This was a straightforward velocity–time question, and candidates who had mastered the concept of area under the graph answered the question well. There was some variety in how candidates visualised the time after 10 seconds, although most candidates did so successfully.

Question 5

This question was successfully completed by candidates who worked through the necessary steps and effectively used their diagrams. Care in constructing diagrams to aid thinking was evident for these candidates.

Question 6

This was an interesting question in that many candidates approached it as a conservation of momentum problem, neglecting the fact that the rocket was steadily accelerating and therefore the exhaust gases would have a range of velocities compared to the initial velocity of the engine. Some work to expand possible approaches would have been helpful.

Sample solutions

The sample solutions on the following pages show possible ways of successfully responding to the questions. Other approaches and problem-solving strategies may be equally valid.

Paper One

Part A Question 1

a) 4 (1)
b) 2 (1)

Part A Question 2

$423.6 \times 0.02 = 8.472$ (1)

$\therefore 423.6 \pm 8.5$ (1)

Part A Question 3

a) $I = \Delta p$
$= m \Delta v$ (1)
$= 900 \times 20$
$= 1.8 \times 10^4$ Ns (1)

b) $W = \Delta E_K$ (1)
$= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$ (1)
$= -\frac{1}{2} \times 900 \times (-20)^2$
$= 1.8 \times 10^5$ J (1)

Part A Question 4

a) $W = mgh$ (1)

$= 2.3 \times 10^3 \times 9.8 \times 30$

$= 676200$

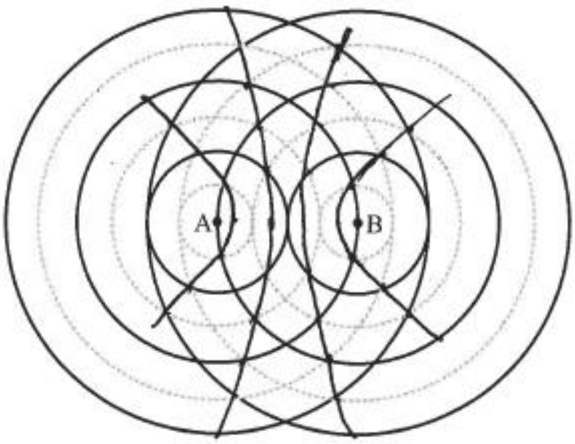
$\Rightarrow 6.8 \times 10^5$ J (1)

$P = W/t$ (1)

$= 6.8 \times 10^5 / 20$

$= 3.4 \times 10^4$ W (1)

Part A Question 5



Part A **Question** 6

$$\lambda = \frac{dx}{L} \quad (1)$$

$$= \frac{5.00 \times 10^{-5} \times 2.80 \times 10^{-2}}{4.20} \quad (1)$$

$$= \underline{3.33 \times 10^{-7}} \text{ m} \quad (1)$$

Part A **Question** 7

$$E = qV = W \quad (2)$$

$$= 2.8 \times 10^{-15} \times 5 \times 10^{3}$$

$$= \underline{1.4 \times 10^{-11}} \text{ J} \quad (1)$$

Part A Question 8

$P = VI$ (1)

$I = P/V$

App 1: App 2:

$I = \frac{2000}{240}$ $I = \frac{1200}{240}$ (1)

$= 8.33\ A$ $= 5A$

(or use 230 V)

(1) ∴ App 2 (Model SG 620)

Part A Question 9

$F = Bqv \sin\theta$ (1)

$= 5.0 \times 10^{-4} \times 1.6 \times 10^{-19} \times 1.5 \times 10^{3} \times \sin 45°$

$= 8.5 \times 10^{-20}\ N$ (1)

Part A Question 10

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He \qquad (\alpha)$$

Change in atomic mass of 4 ↓
Change in atomic number of 2 ↓

$$^{4}_{2}X \Rightarrow {}^{4}_{2}He$$

$$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e \qquad (\beta)$$

✓✓ Total

No change in atomic mass ∴ # p & n unchanged
Increase in atomic number of 1, ∴
change of neutron → proton, i.e. β.

Part B **Question** 1

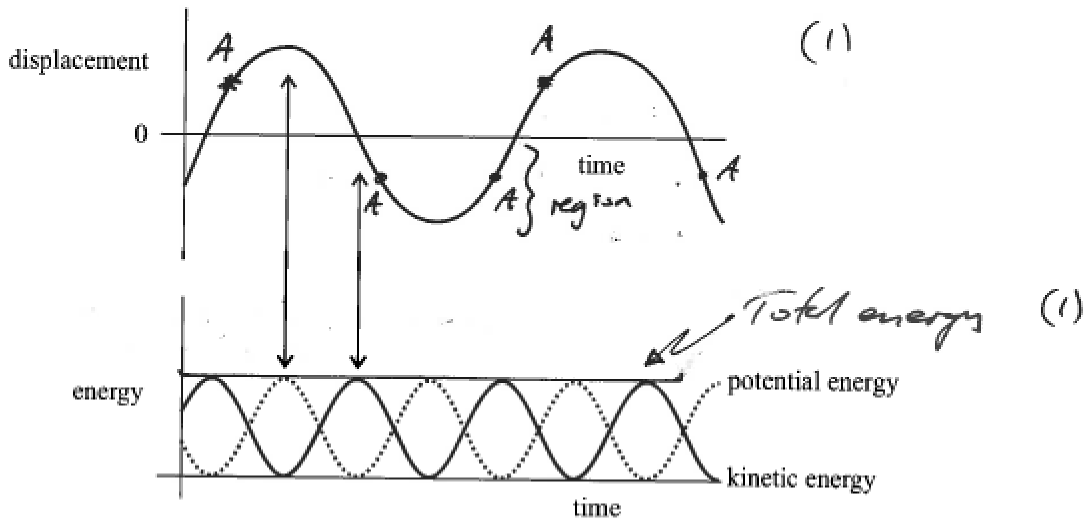
At times when the velocity is constant.

(1) (1)

∴ 22 s – 40 s & 50 s – 70 s

[prior t=0 and post t=70 not necessary)

Part B **Question** 2a and b

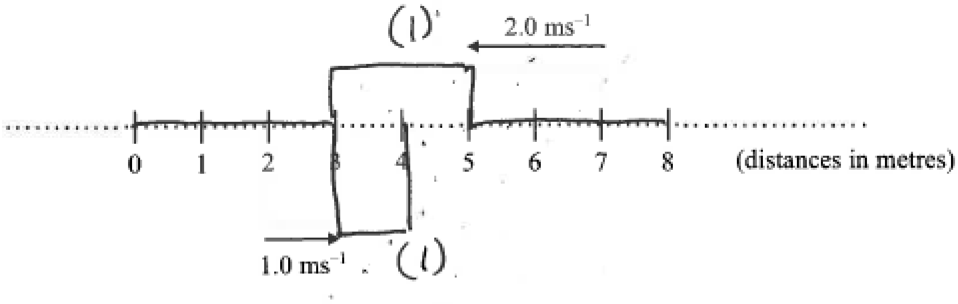


Part B **Question** 2c

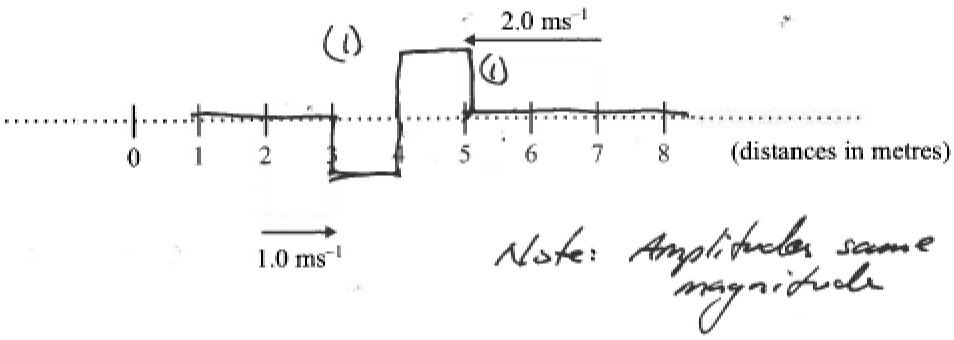
General exponential decline (1)

(Maintain λ) (1)

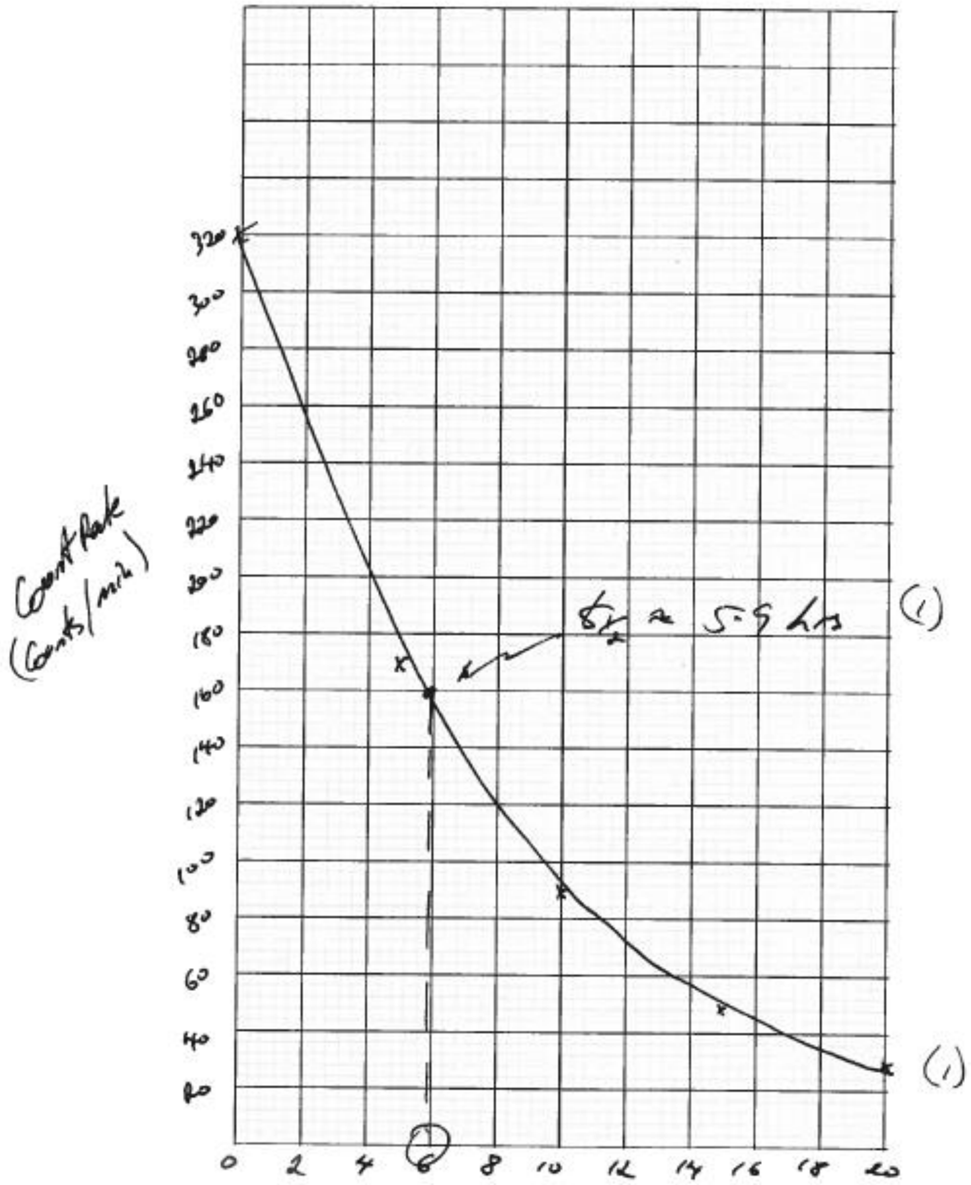
Part **B** Question **3a**



Part **B** Question **3b**



Part B **Question** 4a



Part B **Question** 4b

Likely candidate Mendelevium – 257 (5.53 hrs)
✓ (1) (1)

Part B Question 5

1. PLACE THERMOMETERS IN 2 IDENTICAL 250ml CUPS
2. MAKE ABOUT 500 ml COFFEE AND QUICKLY MEASURE 200 ml HOT COFFEE INTO EACH CUP
3. ADD 10ml MILK (AT 5°C) INTO ONE CUP AND STIR
4. MEASURE TEMPERATURE ~~OF~~ IN EACH CUP
~~5.~~ IMMEDIATELY AND EVERY 30s
5. AT 5MINS, ADD 10ml MILK (AT 5°C) TO OTHER CUP AND STIR
6. IMMEDIATELY RECORD TEMP OF BOTH CUPS
7. GRAPH TEMPERATURE VS TIME FOR BOTH CUPS TO SHOW COOLING RATES
8. DRAW CONCLUSIONS RELATED TO ORIGINAL QUESTION.

Identify variables (1)

Control variables through design (2)

Specify measurements (1)

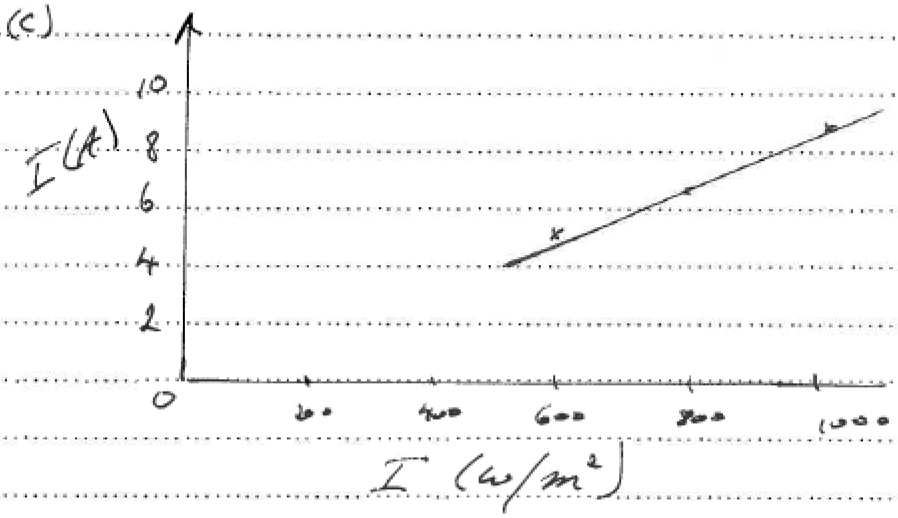
Use of appropriate parameters (1)

Part B Question 6

a) Approx 31 Volts (1)

b) As the voltage increases, the current remains constant. Since $P = VI$, a constant current with increasing voltage results in increasing power. (1) Until just before the maximum, this is linear, i.e. (1) $P \propto V$.

(c)



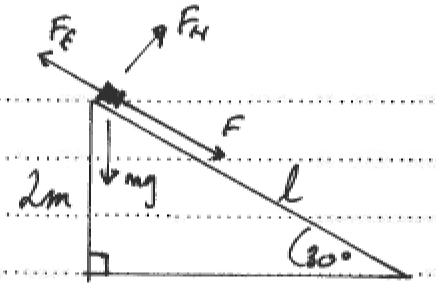
(1)

Close to proportional (1)

Note: Could also be shown by consistent ratios.

Paper Two

Question 1



$F = mg \sin\theta$ $\qquad\qquad$ $F - F_f = 49 - 20$

$= 10 \times 9.8 \times \sin 30$ $\qquad\qquad$ $= 29\text{N}$

$= 49\text{N}$ $\quad$ (1) $\qquad\qquad$ (1)

$a = F/m$ $\qquad\qquad$ $l = 2/\sin 30$

$= 29/10$ $\qquad\qquad$ $= 4\text{ m}$

$= 2.9\text{ ms}^{-2}$ $\quad$ (1)

Using $s = 4\text{m}$, $u = 0\text{ ms}^{-1}$

$s = \cancel{ut} + \frac{1}{2}at^2$

$s = \frac{1}{2}at^2$ $\quad$ (1)

$t = \sqrt{\frac{2s}{a}}$

$= \sqrt{\frac{8}{2.9}}$

$= 1.7\text{ s}$ $\quad$ (1)

Question 2

Consider resistors ($20\,\Omega + 30\,\Omega$) & $80\,\Omega$ in parallel

$$\frac{1}{R_T} = \frac{1}{50} + \frac{1}{80} \quad (1)$$

$$= \frac{8+5}{400} = \frac{13}{400}$$

$$\therefore R_T = 31\,\Omega \quad (1)$$

A_1 : $V = IR_T$
$I = V/R_T$
$= 12/31$
$= \underline{0.39\ A}$ (1)

A_2 : $V = I.80$
$I = V/80$
$= 12/80$
$= \underline{0.15\ A}$ (1)

V: $I = 12/50$
$= 0.24A$

$\therefore I = 0.24A$
$R = 20\,\Omega$
$V = IR$
$= 0.24 \times 20$
$= \underline{4.8V}$ (1)

Question 3

Using the spring constant:

$F = kx$ (1)

$k = F/x$

$= (80 \times 9.8)/0.2$

$= 3920\ N/m$

When maximum displacement is 1.2 m:

$E = \frac{1}{2} kx^2$ (1)

$= \frac{1}{2} \times 3920 \times (1.2)^2$

$= 2.8 \times 10^3\ J$ (1)

$\therefore$ Max GPE $= 2.8 \times 10^3\ J = mgh$ (1)

$2.8 \times 10^3 = 80 \times 9.8 \times h$

$h = \dfrac{2.8 \times 10^3}{80 \times 9.8}$

$\underline{= 3.6\ m}$ (1)

Question 4

Calculating area under graph:

X: $s = (10 \times 4) + (5 \times 3)$

$= 40 + 15$

$= 55$ m (1)

Y: $s = (10 \times 10)/2$

$= 50$ m (1)

a) Since X is ahead at $t = 10$ s and they have the same speed from then on, X must win the race. (1)

b) Regardless of the duration of the race, Y is behind X by 5 m from $t = 10$ onwards.

$\therefore$ 5 m at 10 ms^{-1}

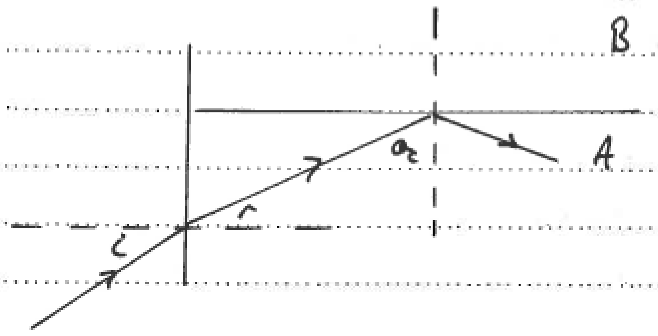
$t = s/v$

$= 5/10$

$= 0.5$ s (1)

$\therefore$ Y crosses 0.5 s later. (1)

Question 5



$n_A \sin\theta_A = n_B \sin\theta_B$

$\frac{\sin\theta_A}{\sin\theta_B} = \frac{n_B}{n_A}$

at θ_c, $\sin\theta_B = 1$ (1)

$\therefore \sin\theta_c = \frac{n_B}{n_A} = \frac{1.52}{1.62} = 0.938$

$\therefore \underline{\theta_c = 69.8°}$ (1)

$\therefore r = 90 - 69.8 = 20.2°$ (1)

$n_A = \frac{\sin i}{\sin r}$ (1)

$\sin i = n_A \sin r$

$= 1.62 \times \sin(20.2)$

$= 0.5594$

$\therefore \underline{i = 34°}$ (1)

Question 6

Since $a = F/m$ and F = constant (1)

$a \propto 1/m \therefore a_{av} = \frac{a_f - a_i}{2}$

$F = \frac{m\Delta v}{t} = \frac{75 \times 5000}{1} = \underline{375\,000\ N}$ (1)

$a = \frac{F}{m}$ $\quad F = 375\,000\ N$

$m_f = 20\,000\ kg$ (1)

$m_i = 50\,000\ kg$

$\therefore a_f = 375\,000 / 20\,000$

$= 18.75\ ms^{-2}$

$a_i = 375\,000 / 50\,000$

$= 7.5\ ms^{-2}$

$\therefore a_{av} = \frac{a_f + a_i}{2}$

$= \underline{13\ ms^{-2}}$ (1)