Neap:

VCE BIOLOGY, CHEMISTRY, PHYSICS, MATHS METHODS (CAS) & SPECIALIST MATHS

VCE INTENSIVE PROGRAMS SEMESTER 2 2011

Sample questions

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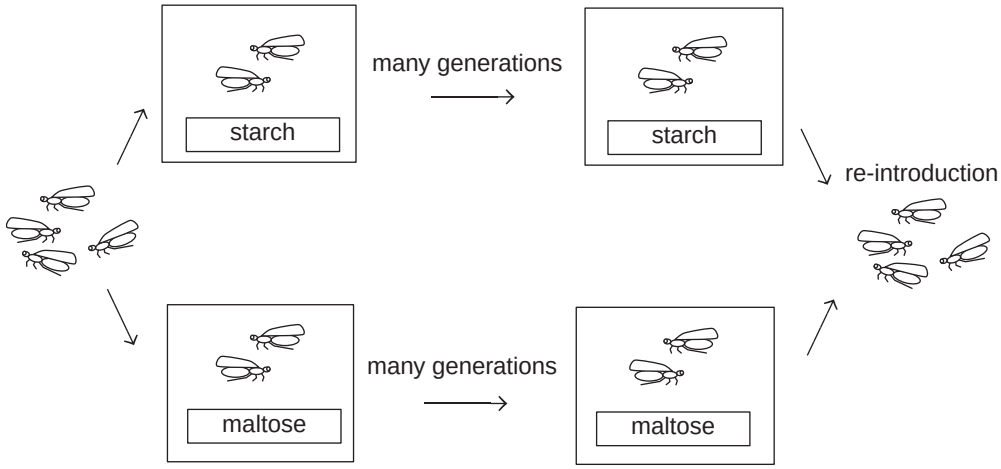
1. Biology Unit 4 Intensive Program

Question 1.1

A student took 1000 fruit flies of the same species from a population and divided them into two equal populations living in different cages. One of the populations lived on maltose-based food, and the other population lived on starch-based food. After many generations, the two populations of flies were reintroduced to each other. The flies were then tested to see which flies they preferred to mate with. The experimental procedure is shown in the diagram below.



The 'maltose flies' preferred to breed with other 'maltose flies', although if 'maltose flies' were not available, they would breed with 'starch flies'. Similarly, 'starch flies' preferred to breed with other 'starch flies', but they would still mate with 'maltose flies'.

From these results, it was reasonable for the student to conclude that

A. two new species of fruit flies had evolved.

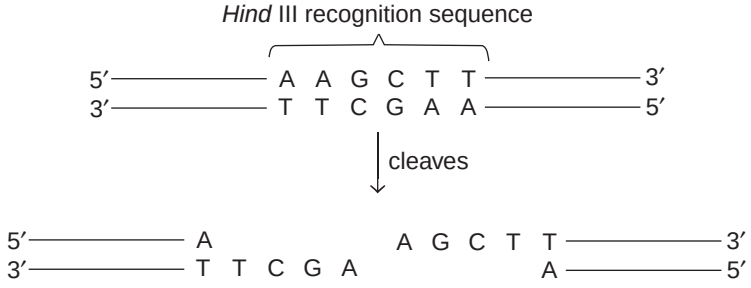
B. reproductive isolation had begun to occur as a result of the geographic isolation of the two populations.

C. the flies had undergone genetic drift and could not produce viable gametes.

D. the flies had evolved different reproductive organs due to their different diets and this was preventing them from interbreeding.

Question 1.2

Hind III is a restriction enzyme derived from the bacterium *Haemophilus influenzae*. The diagram below shows the effect of this enzyme on DNA.



a. A plasmid to be used in genetic modification contains this recognition sequence at five locations.

If the plasmid was digested with *Hind* III, how many fragments of DNA would be formed?

_____

An autosomal recessive inherited disorder runs in the Jones family. An allele specifying the production of a normal protein (**R**) is 160 kbp in length and has a recognition sequence for *Hind* III halfway along its length. The mutant allele (**r**) has a second restriction site, 60 kbp beyond the midway point of the gene.

b. Describe the DNA fragments resulting from

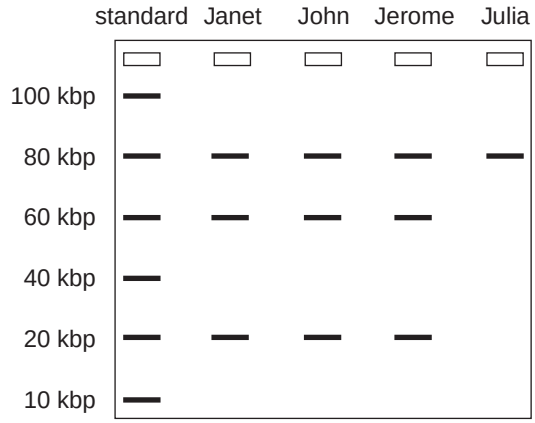
i. the restriction of the normal allele by *Hind* III.

_____

ii. the restriction of the mutant allele by *Hind* III.

_____

The parents in the Jones family, Janet and John, decided to have themselves and their two children, Jerome and Julia, screened for the disease. Their DNA samples were digested with *Hind* III and separated using gel electrophoresis. The gel was then treated with a gene probe to detect DNA contained in the gene. The distribution of DNA fragments on the resulting gel is shown below.



c. **i.** After digestion with *Hind* III, describe how gel electrophoresis enables a band pattern to appear on the gel.

_____

_____

_____

_____

ii. What is a ‘gene probe’?

_____

_____

iii. Explain the purpose of the standard DNA.

_____

_____

d. Which individual(s) carry at least one copy of the mutant allele, **r**? Explain.

_____

_____

2. Chemistry Unit 4 Intensive Program

Question 2.1

At 40°C, the hydronium ion concentration in pure water is 1.71×10^{-7} M.

Pure water at 40°C will therefore

A. be acidic with a pH of 6.8.

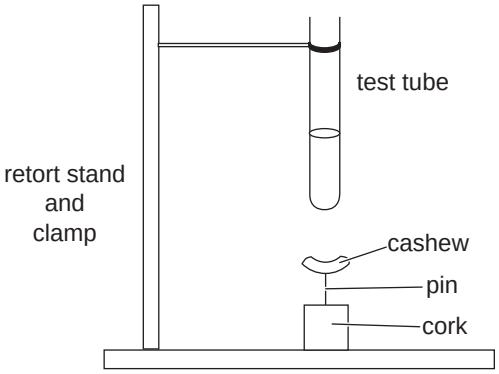
B. contain hydroxide ions at a concentration of 5.85×10^{-8} M.

C. contain less ions than water at 25°C.

D. have a K_w value of 2.92×10^{-14} M^2.

Question 2.2

An experiment was conducted to determine the energy content of an unsalted cashew nut.



The cashew nut was weighed before and after burning, and the temperature of the water measured before and after heating by the burning cashew. The results recorded are shown below.

volume of water used	20.00 mL
initial mass of cashew	2.050 g
final mass of cashew	0.860 g
initial temperature of water	18.50°C
final temperature of water	77.90°C

a. Given that the specific heat capacity of water is 4.18 Jg^{-1} $°C^{-1}$, determine the amount of energy used to heat the water.

_____

_____

b. Hence determine the energy content of the cashew nut in J g^{-1}.

_____

_____

c. The label on the packet of cashew nuts provided the following information for 100 g of nuts.

18 g protein, 47 g fat, 28 g carbohydrate, 2407 kJ of energy

Determine the percentage of the energy from the burning cashew transferred to the water.

d. Describe one modification which could be made to the experimental design to improve the accuracy of the results.

Question 2.3

Electroplating is a relatively inexpensive way of producing costume jewellery. In a particular electroplating cell, a metal cross was to be electroplated with silver. A current of 0.350 A was used to deposit 6.20 mg of silver onto the cross from a silver nitrate solution.

a. Determine the time required to electroplate the cross with silver.

b. Gold was used in another cell to plate another identical cross.

If the same current was used for the same length of time and a mass of 5.66 mg of gold was deposited, what was the charge of the gold ion present in the electrolyte solution?

c. In order to set up the electroplating cells described above, should the cross be connected to the positive or negative electrode? Explain your choice.

3. Physics Unit 4 Intensive Program

Question 3.1

Explain the purpose of the split-ring commutator in the DC motor.

Question 3.2

In order to investigate interference of light, students shone light of wavelength 650 nm through two slits as shown in Figure 1.

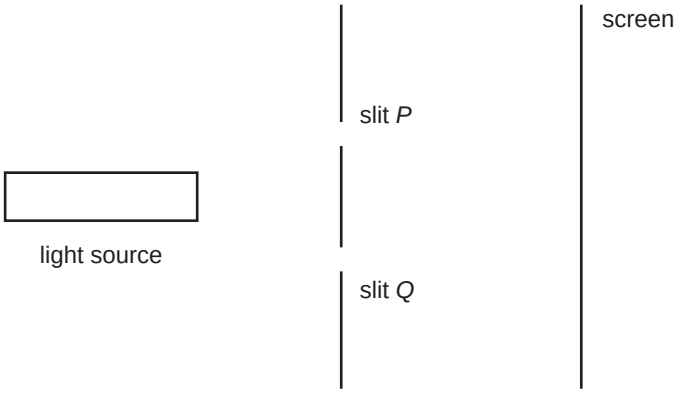


Figure 1

The resulting interference pattern of light and dark bands observed on the screen is shown in Figure 2.

Figure 2

Explain how the dark bands on the screen are produced.

Question 3.3

Adela, a senior physics student, is doing some simple practicals in electromagnetic induction. One experiment involves pushing the north end of a magnet into a circular conducting loop of wire as shown in Figure 3.

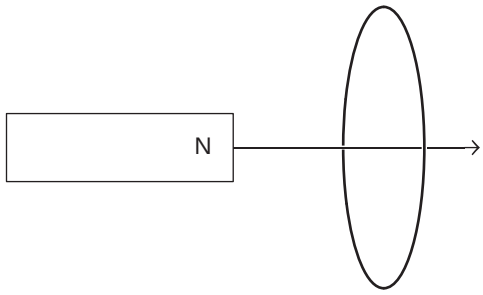


Figure 3

a. Draw in the induced magnetic field on Figure 3.

b. Draw in on Figure 3 the direction of the induced current in the circular conducting loop of wire.

4. Maths Methods (CAS) Units 3&4 Intensive Program

Question 4.1

Given that $m > n > 0$, $\log_e\left(\frac{1}{m^2 - n^2}\right)$ is equal to

A. $-2\log_e(m) + 2\log_e(n)$

B. $-\log_e(m - n) - \log_e(m + n)$

C. $-\log_e(2m) + \log_e(2n)$

D. $\log_e(m - n) + \log_e(m + n)$

E. $-2\log_e\left(\frac{m}{n}\right)$

Question 4.2

The graph of the function with rule $y = \log_e|x|$ is transformed as follows:

- A dilation by a factor of $\frac{1}{3}$ from the y-axis;
- a translation of –3 units parallel to the x-axis; and then
- a reflection in the y-axis.

The rule of the function corresponding to the transformed graph is

A. $y = -\log_e|9 - 3x|$

B. $y = \log_e|9 - 3x|$

C. $y = -\log_e|3 - 3x|$

D. $y = -\log_e\left|1 - \frac{1}{3}x\right|$

E. $y = \log_e\left|1 - \frac{1}{3}x\right|$

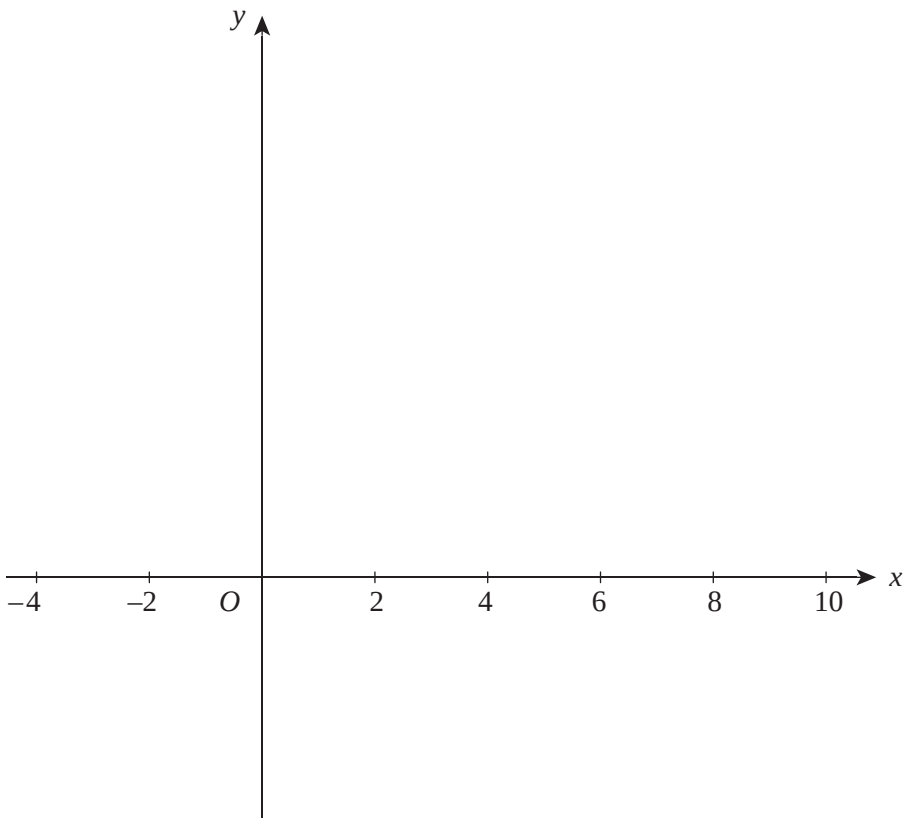
Question 4.3

The probability density function, $f(x)$, of the continuous random variable X, is defined by

$$f(x) = \begin{cases} \frac{k}{x^2}, & 1 \leq x \leq 6 \\ 0, & \text{otherwise} \end{cases}$$

a. Find the value of k.

b. Sketch the graph of $y = f(x)$ on the axes provided.



5. Specialist Maths Units 3&4 Intensive Program

Question 5.1

A particle moves in the x–y plane with a velocity vector given by $\dot{\underset{\sim}{r}}(t) = e^{-t}\underset{\sim}{i} - 3e^{-3t}\underset{\sim}{j}$ for $t \geq 0$. At $t = 0$, the particle is at the origin, i.e. $\underset{\sim}{r} = \underset{\sim}{0}$.

$\underset{\sim}{r}(t)$ is equal to

A. $(1 - e^{-t})\underset{\sim}{i} + (e^{-3t} - 1)\underset{\sim}{j}$

B. $-e^{-t}\underset{\sim}{i} + 9e^{-3t}\underset{\sim}{j}$

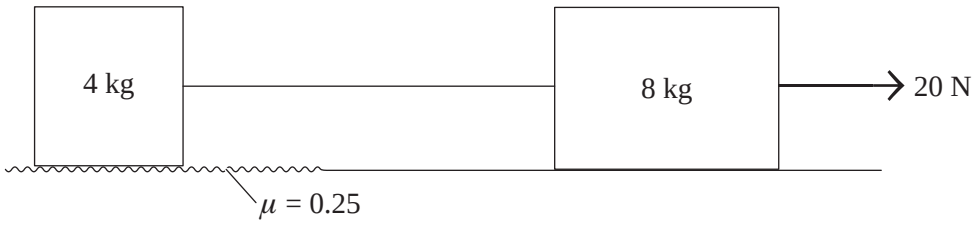
C. $-e^{-t}\underset{\sim}{i} + e^{-3t}\underset{\sim}{j}$

D. $(e^{-t} - 1)\underset{\sim}{i} + (1 - e^{-3t})\underset{\sim}{j}$

E. $-(1 + e^{-t})\underset{\sim}{i} + (1 - e^{-3t})\underset{\sim}{j}$

Question 5.2

The diagram below shows a horizontal force of 20 N being applied to an 8 kg mass which sits on a frictionless section of a horizontal surface. The 8 kg mass is joined by a light, inextensible string to a 4 kg mass which sits on the same horizontal surface but on a section which has a coefficient of friction of 0.25.



a. On the diagram above, label all the forces acting on each mass.

b. Let a m/s^2 be the acceleration of the system for the length of time that the 4 kg mass remains on the section for which friction applies. Find the value of a, giving your answer in terms of g.

Question 5.3

A particle moves in the x–y plane so that after t seconds its velocity is given by

$\dot{\underset{\sim}{r}}(t) = (9t - 3t^2)\underset{\sim}{i} + \log_e(1 + (t - 3)^4)\underset{\sim}{j}$ m/s, $t \geq 0$.

a. Find the speed of the particle when $t = 1$, correct to two decimal places.

b. Find when the particle is at rest.

c. Find the gradient of the curve along which the particle moves when $t = 1$, correct to two decimal places.

6. Solutions to sample questions

Biology Unit 4 Intensive Program

Question 1.1 B

A is incorrect because there is evidence that the flies can still interbreed. **C** is unlikely because genetic drift is a random process affecting small populations and is not obviously linked to gamete viability. **D** is unlikely since no reasonable connection can be made between the selective pressure (diet) and its effect (different reproductive organs).

Question 1.2

a. five

b. **i.** two fragments, each 80 kbp in length

ii. one 80 kbp fragment, one 60 kbp fragment and one 20 kbp fragment

c. **i.** Fragments of DNA are negatively charged. Therefore in an electric current, fragments move through the gel towards the positive terminal. Smaller fragments of DNA move further through the gel.

ii. A gene probe is a length of single-stranded DNA (or sometimes RNA) that binds to a specific sequence of bases. It also contains a fluorescent or radioactive label or marker. Gene probes can be used to locate a specific locus (gene or allele) in a DNA fragment.

iii. Standard DNA, when digested, produces fragments of known sizes against which the size of fragments of sample DNA can be compared.
OR
Standard DNA, when digested, produces a known number of fragments. When the standard fragments appear on the gel, they show that the gel electrophoresis has occurred correctly.

d. Janet, John and Jerome all carry the mutant allele since their DNA for this locus has been digested into three fragments, i.e. 20, 60 and 80 kbp fragments which are characteristic of the digested mutant allele.

Chemistry Unit 4 Intensive Program

Question 2.1 D

$[H_3O^+] = 1.71 \times 10^{-7}$ M

$\therefore [OH^-] = 1.71 \times 10^{-7}$ M ($[H_3O^+] = [OH^-]$ in pure water)

$K_W = [H_3O^+][OH^-] = (1.71 \times 10^{-7})^2 = 2.92 \times 10^{-14}$ M^2

Since $[H_3O^+] > 10^{-7}$ M, there are more ions than at 25°C, so **C** is incorrect. Pure water is neutral at all temperatures, since $[H_3O^+] = [OH^-]$, so **A** is incorrect. $[OH^-] = 1.71 \times 10^{-7}$ M, so **B** is incorrect.

Question 2.2

a. $E = m \times c \times \Delta T = 20.00 \times 4.18 \times (77.90 - 18.50) = 4966$ J = 4.97 kJ

b. energy = $\dfrac{4966}{(2.050 - 0.860)} = 4173$ J $g^{-1} = 4.17 \times 10^3$ J g^{-1}

c. energy (via experiment) = 4.173 kJ g^{-1}

energy (via food label) = 24.07 kJ g^{-1}

% transfer = $\left(\dfrac{4.173}{24.07}\right) \times 100 = 17.3\%$

d. Either one of

- insulation of test tube to ensure no loss of heat from the water;
- insulation of the heat from the cashew to direct it to the test tube and prevent heat escaping to the environment.

Question 2.3

a. $n(\text{Ag}) = \frac{m}{M} = \frac{6.20 \times 10^{-3}}{107.9} = 5.746 \times 10^{-5}$ mol

$n(e^-) = n(\text{Ag}) = 5.746 \times 10^{-5}$

$t = \frac{n(e^-) \times F}{I} = \frac{(5.746 \times 10^{-5} \times 96\ 500)}{0.350} = 15.8$ s

b. $n(\text{Au}) = \frac{m}{M} = \frac{5.66 \times 10^{-3}}{197.0} = 2.873 \times 10^{-5}$ mol

$n(e^-) = 5.746 \times 10^{-5}$ mol (same conditions as part **a**)

$n(e^-) \div n(\text{Au}) = 5.746 \times 10^{-5} \div (2.873 \times 10^{-5}) = 2$

Therefore the gold ions in solution are Au^{2+}.

c. Negative, because this is the cathode, so that the forced reduction of Au^{2+} ions occurs.

Physics Unit 4 Intensive Program

Question 3.1

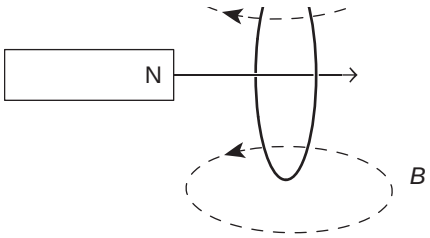
The split-ring commutator in the DC motor reverses the current every half a cycle. The means that the magnetic forces acting on each side also swap over every half a cycle so that the DC motor continually keeps rotating in one direction. Without the split-ring commutator, the coil would turn and eventually stop at 90°.

Question 3.2

Waves from slit *P* and slit *Q* travel distances that differ by $\left(n - \frac{1}{2}\right)\lambda$ to points on the screen and hence arrive out of phase with one another. If the waves are out of phase, then destructive interference occurs and this produces the dark bands.

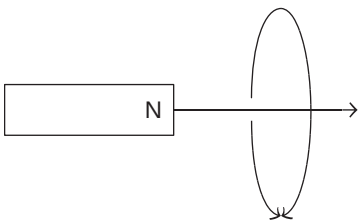
Question 3.3

a.



Note that, by Lenz's law, the induced field opposes the field producing it.

b.



Maths Methods (CAS) Units 3&4 Intensive Program

Question 4.1 **B**

$$\log_e\left(\frac{1}{m^2 - n^2}\right) = \log_e(m^2 - n^2)^{-1}$$
$$= -\log_e(m^2 - n^2)$$
$$= -\log_e((m - n)(m + n))$$
$$= -\log_e(m - n) - \log_e(m + n)$$

Question 4.2 **B**

$y = \log_e|x|$ becomes $y = \log_e|3x|$ after a dilation of a factor of $\frac{1}{3}$ from the y-axis.

$y = \log_e|3x|$ becomes $y = \log_e|3(x + 3)|$ after a translation of -3 units parallel to the x-axis.

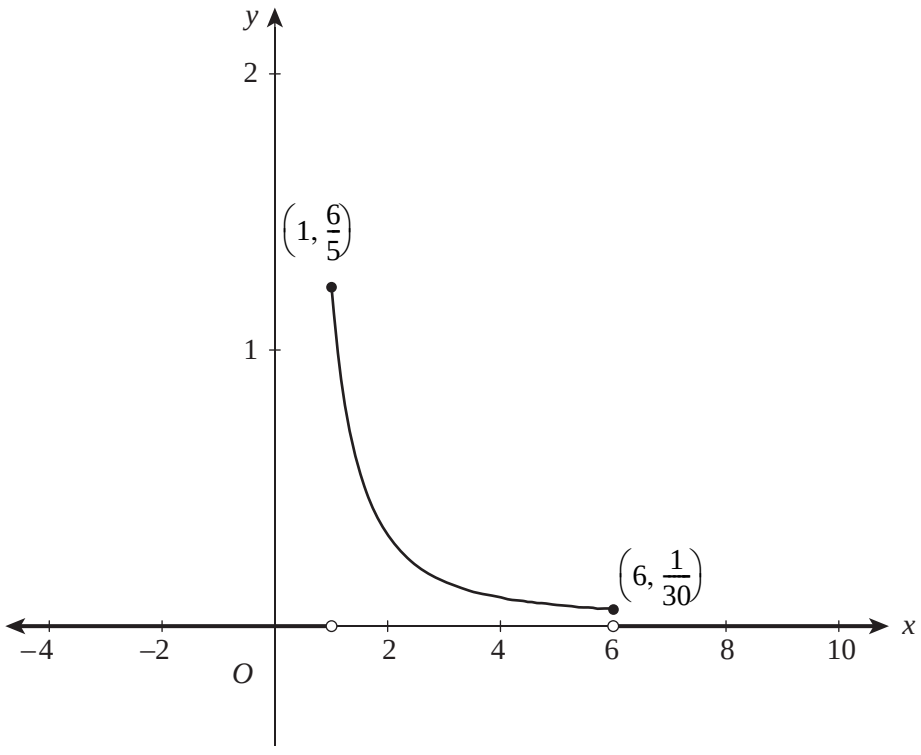
$y = \log_e|3(x + 3)|$ becomes $y = \log_e|3(-x + 3)| = \log_e|-3x + 9|$ after a reflection in the y-axis.

Question 4.3

a. As $f(x)$ is a probability density function, $\int_1^6 \frac{k}{x^2}dx = 1$.

$$\left[-\frac{k}{x}\right]_1^6 = 1$$
$$-\frac{k}{6} + \frac{k}{1} = 1$$
$$k = \frac{6}{5}$$

b.



Correct endpoints

Correct graph on $(-\infty, \infty)$

Specialist Maths Units 3&4 Intensive Program

Question 5.1 **A**

$$\underset{\sim}{r}(t) = \int (e^{-t}\underset{\sim}{i} - 3e^{-3t}\underset{\sim}{j})dt$$

$$= -e^{-t}\underset{\sim}{i} + e^{-3t}\underset{\sim}{j} + \underset{\sim}{d}$$

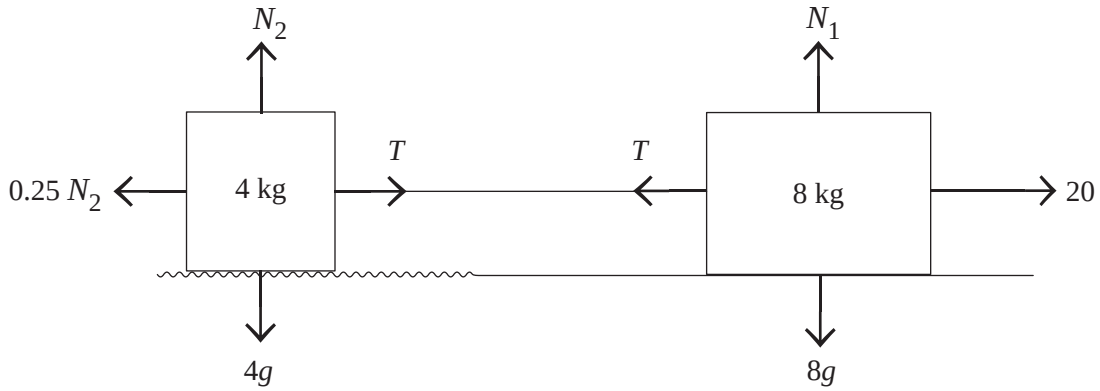
When $t = 0$, $\underset{\sim}{r} = \underset{\sim}{0}$.

$$\underset{\sim}{d} = \underset{\sim}{i} - \underset{\sim}{j}$$

$$\underset{\sim}{r}(t) = (1 - e^{-t})\underset{\sim}{i} + (e^{-3t} - 1)\underset{\sim}{j}$$

Question 5.2

a.



b. Resolving horizontally for the 8 kg mass, $20 - T = 8a$ (1)
Resolving vertically for the 4 kg mass, $N_2 = 4g$ (2)
Resolving horizontally for the 4 kg mass, $T - 0.25N_2 = 4a$ (3)
Substituting (2) into (3) gives $T - g = 4a$ (4)
Adding (1) and (4) gives $20 - g = 12a$

Thus $a = \dfrac{20 - g}{12}$.

Question 5.3

a. $\left|\dot{\underset{\sim}{r}}(t)\right| = \sqrt{(9t - 3t^2)^2 + (\log_e(1 + (t-3)^4))^2}$

$\left|\dot{\underset{\sim}{r}}(1)\right| = \sqrt{(9 - 3)^2 + (\log_e(1 + (1-3)^4))^2}$

Hence $\left|\dot{\underset{\sim}{r}}(1)\right| = 6.64$, i.e. the particle's speed is 6.64 m/s (correct to two decimal places).

b. Attempting to solve $9t - 3t^2 = 0$ **and** $\log_e(1 + (t-3)^4) = 0$ for t:

From $9t - 3t^2 = 0$ we obtain $t = 0, 3$ and from $\log_e(1 + (t-3)^4) = 0$ we obtain $t = 3$.

Hence the particle is a rest at $t = 3$.

c. The gradient of the curve is given by $\dfrac{dy}{dx} = \dfrac{\left(\dfrac{dy}{dt}\right)}{\left(\dfrac{dx}{dt}\right)}$.

At $t = 1$, $\dfrac{dy}{dx} = \dfrac{\log_e(17)}{6} = 0.47$ (correct to two decimal places).