GENERAL COMMENTS

The number of students who actually sat for the examination was 686. The students found it to be a reasonably demanding paper. This can be partly attributed to the fact that it was a new course and the revision material available to students was very limited in some areas. Despite this one student achieved the maximum score of 90.

When assessing the scripts it appeared that a substantial number of students had difficulty with the length of the examination. It was particularly surprising to see so many multiple choice questions not attempted.

A number of concerns became evident while marking the student scripts.

- Teacher(s) would be well advised to emphasise to their students that they should attempt questions from only one of the detailed studies. Considerable numbers of students attempted two or three of these.
- Some students need to be more careful with their writing. If the assessor cannot decipher it, there will not be any marks awarded. This applies particularly to multiple choice questions where one answer is written over another.
- Written explanations must address the specifics of the question asked. Simply copying generic answers from their A4 sheets will not gain full marks for students. They should be encouraged to re-read their explanations to ensure that they have answered the question asked and that what they have written makes sense. Diagrams can be a valuable aid in answering these questions, but must be done with reasonable care to ensure that their key features are clear.
- There appeared to be some improvement in students' ability to perform numerical calculations. However, there were still examples of students who were able to identify the correct equation and substitute properly, but were then unable to determine the final answer. This was either because of an inability to transpose the formula or a problem with using the calculator correctly.
- It was clear that some students have trouble with unit conversions, eg. from A to mA.
- The number of students who misunderstood simple series circuits is still a concern.
- Students should be encouraged to follow the instructions given in questions. For example, Electronics and Photonics required a sketch and students could not obtain full marks without one.
- Questions related to AC signal voltages caused difficulties for students in the Electronics and Photonics section. Some students appeared to be confused by the terms peak and peak-peak, and how they relate to DC and RMS.

SPECIFIC INFORMATION

Section A - Core

Area of study 1 – Motion in one and two dimensions
Question 1 to Question 3

Marks	0	1	2	3	4	5	6	7	Average
%	10	10	13	18	13	20	4	12	**3.52**

Question 1

By first determining the vertical component of the package's velocity as 5 m s^{-1} it was then possible to use a constant acceleration formula to find the height of **30 m**. Many students had difficulty with the vector nature of the constant acceleration formula. (Average mark 1.7)

Question 2

The helicopter and the package had the same horizontal component of velocity so the correct response was **A**. 58% of students selected this, while 18% chose C. (Average mark 1.2)

Question 3

The correct answer **B** was selected by only 40% of students. It was disappointing that 44% chose D which indicated they thought the package came to a complete stop at the top of its path. (Average mark 0.8)

Question 4 to Question 6

Marks	0	1	2	3	4	5	6	7	8	9	10	Average
%	8	2	1	7	7	3	4	21	3	3	40	**6.97**

Question 4

The momentum gained by the truck was equal to the momentum lost by the car which was **3000 kg m $^{-1}$**. The most common error was to simply calculate the initial momentum of the car. (Average mark 1.8)

Question 5

This question was well done. The mass of the truck was **1500 kg**. (Average mark 2.6)

Question 6

This question was also well done. The impulse exerted on the truck is equal to its change in momentum which has already been calculated as 3000 kg m s $^{-1}$. So the average force acting is 10 000 N. (Average mark 2.8)

Questions 7 and Question 8

Marks	0	1	2	3	4	5	Average
%	7	3	10	9	25	46	**3.8**

Question 7

From inside the train the ball would be seen to move directly up then down. There were quite a number of students who believed that the ball would go up and backward over Lee's head. (Average mark 1.7)

Question 8

From Sam's perspective at the level crossing the ball would appear to follow a parabolic path with the horizontal component of its velocity equal to that of the train. Once again some students believed Sam would see the ball go backward over Lee's head. (Average mark 2.1)

Question 9 to Question 11

Marks	0	1	2	3	4	5	6	7	Average
%	17	2	14	6	12	12	5	31	**4.1**

Question 9

Since the speed is constant the net force must be zero. Therefore the driving force must equal the retarding force of **800 N**. (Average mark 1.7)

Question 10

To find the tension in the tow bar students needed to examine the forces acting on the van or the car. The car is the simplest since the only forces acting on it are the tension in tow bar forward and 300 N backward. So the tension is **300 N**. (Average mark 1.3)

Question 11

The simplest way to approach this question was to equate change in kinetic energy to the work done. The net force acting is 800 N. So the distance required is **422 m**. However, very few students used this approach. Most used Newton's second law to calculate the acceleration, which was then used in a constant acceleration formula to calculate the distance. Many who were able to determine the acceleration had difficulty applying the constant acceleration formula. (Average mark 1.6)

Questions 12 and Question 13

Marks	0	1	2	3	4	Average
%	18	42	8	12	20	**1.74**

Question 12

Most students were able to correctly draw an arrow directly toward the sun. (Average mark 0.8)

Question 13

By equating the gravitational field strength to the centripetal acceleration and transposing, the formula for the mass of the Sun is $M = \frac{4\pi^2 R^3}{GT^2}$. By substituting the appropriate values the mass of the Sun is **$2.0x10^{30}$ kg**. It was surprising how many students did not know the period of the Earth's orbit around the Sun is ≈ 365 days. Also the number of students who were able to deduce the correct formula was rather limited. (Average mark 0.8)

Question 14 and Question 15

Marks	0	1	2	3	4	5	6	7	Average
%	32	6	11	11	7	21	2	10	**2.74**

Question 14

The most straightforward approach was to equate the gravitational potential energy at the top of the ramp to the sum of the kinetic energy at the bottom plus the energy lost to work done against friction on the way down the ramp. This gave an answer for the height of **4.2 m**. Very few students managed to deal with the work done against friction. (Average mark 0.9)

Question 15

By equating the kinetic energy of the box to the energy stored in the spring ($\frac{1}{2} k x^2$) students were able to determine the compression of the spring to be **0.25 m**. About 50% of students were able to answer this question. (Average mark 1.6)

Area of study 2 – Electronics and photonics

Question 1 to Question 4

Marks	0	1	2	3	4	5	6	7	8	9	Average
%	5	4	7	6	9	9	12	14	16	17	**5.71**

Question 1

This was a simple voltage divider where the answer came out to **20 kΩ**. The question was generally well done. The most common error was mixing up R_1 and R_2. (Average mark 1.5)

Question 2

A simple diagram of two 10 kΩ resistors in parallel was required. Students coped with this quite well although some did not provide the required sketch. (Average mark 1.4)

Question 3

Since it is a series circuit the current through R_2 is the same as for the whole circuit. Therefore Ohm's Law can be applied to the circuit, $100x10^{-3} = I \times 20x10^3$ to obtain an answer of **5 μA**. The assessors predicted that some students may have been confused about peak-peak, peak and RMS values. This did not appear to be the case. The main errors involved either using 30 V from the previous questions instead of 100 mV or using just one of the resistors instead of the total. (Average mark 1.1)

Question 4

For DC (and low frequency AC) the capacitor blocks the current (acts like an open circuit/infinite resistance). So the current passes through R_1. At high frequency AC the capacitor allows current to flow. (Acts like a short circuit/zero resistance) The marking scheme allowed for students to score reasonably well. Many students referred to a decoupling capacitor which was totally irrelevant. (Average mark 1.8)

Question 5 and Question 6

Marks	0	1	2	3	4	Average
%	16	4	38	11	30	**2.35**

Question 5

This was a four stage problem. First the AC collector current (peak-peak) had to be calculated using the relationship $i_C = 100\ i_B = 0.001$ A. Then by using Ohm's Law the AC voltage (peak-peak) across the collector could be determined. $v = 0.001 \times 2\text{x}10^3 = 2$ V Now, realising that the AC voltage across the collector is the same as that across the output the gain is $2/(10\text{x}10^{-3})$ = **200**. Students had to show evidence of the first steps to obtain marks as the answer was given in the stem. There was some evidence that students were unsure how to treat the peak-peak voltages and currents. Many scripts showed confusion between the DC biasing and the AC signal voltages. Some students were able to determine the signal voltage across the collector but then subtracted this from the DC supply of 20 V to get an output of 18 V. Given the number of steps involved it is perhaps not surprising that students found this a fairly difficult question. (Average mark 0.8)

Question 6

The correct answer **B** was selected by 42% of students. 32% chose D and 20% chose A. (Average mark 1.4)

Question 7 to Question 10

Marks	0	1	2	3	4	5	6	7	8	Average
%	4	3	12	11	15	12	19	7	17	**4.76**

Question 7

A current of 10 mA through the LED required 1.5 V. Therefore the voltage across R_D was 8.5 V. Applying Ohm's Law then gave a value of **850 Ω** for R_D. The number of students who assumed the entire 10 V was across the resistor R_D was disappointing. Another common error was to use the voltage across the LED instead of across the resistor. (Average mark 1.2)

Question 8

The voltage across R_D is not affected by reducing the resistance of R_D since the LED still uses 1.5 V. Therefore reducing the resistance of R_D will increase the current. An increased current through the LED will increase the light output. A large group of students thought that by decreasing the resistance of R_D the voltage across it would decrease. (Average mark 1.2)

Question 9

Approximately 75% of students selected the correct answer **C**. About 20% selected B which indicated they thought the LED was 100% efficient. (Average mark 1.6)

Question 10

The correct answer **C** was selected by about 48% of students. As the light intensity increases the collector current increases and more of the supply voltage is used by R_C. Therefore less voltage is available at V_{OUT}. A further 29% of students chose A and 19% chose B. This question indicated a rather poor understanding of the behaviour of a phototransistor by half the students. (Average mark 1.0)

Question 11 and Question 12

Marks	0	1	2	3	4	Average
%	21	21	23	22	12	**1.82**

Question 11

Very few managed to get the correct answer for this question.

However, the marking scheme was designed to reward students who demonstrated a good understanding of the operation of the device. The correct low level of the current I_C had to be determined as **2 mA** for 1 mark, and the second mark was awarded for showing how the current dropped from 4 mA to 2 mA. (Average mark 0.9)

Question 12

Bandwidth refers to the range of frequencies passed with limited attenuation and is measured in Hz, MHz, bps etc. There was considerable evidence of confusion about the definition. (Average mark 1.1)

Section B – Detailed studies

Detailed study 1 – Einstein's relativity

Question 1 to Question 3

Marks	0	1	2	3	4	5	6	Average
%	4	10	11	25	15	17	18	**3.61**

Question 1

Most students were able to select the correct answer of **Bruce**.

Question 2

The answer was **A** and **B**. Students were generally able to select either one or both of these.

Question 3

The correct answer **B** was a reasonably popular choice.

Question 4 to Question 6

Marks	0	1	2	3	4	5	6	Average
%	20	6	26	6	36	1	5	**2.55**

Question 4

To answer this question required a simple application of the kinetic energy formula $E_K = \frac{1}{2} mv^2$. The kinetic energy and mass were given so the speed was **1.5×10^9**. Some tried to answer this using a relativity equation.

Question 5

Students did not find this question as easy as it appeared to be. To obtain the answer **B** students had to extrapolate the graph to a kinetic energy of 10×10^{-13} J and read off the value of v^2. A common selection was D (cannot be estimated). Presumably students were unhappy about extrapolating the graph.

Question 6

Few students selected the correct answer **D**, the majority chose C, which indicated that they really did not understand how a positive result would be indicated in the experiment.

Question 7 and Question 8

Marks	0	1	2	3	4	5	Average
%	28	21	31	12	8	1	**1.56**

Question 7

One mark was given for indicating the predicted difference in travel times in the two perpendicular directions OR that they were attempting to measure the speed of the Earth with respect to the ether OR that they were trying to compare the speed of light parallel to and perpendicular to the motion of the Earth through the ether. The second mark was for explaining that rotating the apparatus was expected to produce a shift in the interference pattern. The third mark was given for stating that no shift in the interference fringes was observed OR that the speed of light was the same in both directions OR that the experiment produced no evidence to support the idea of motion through the ether. Few students received full marks for this question. About half received 2 marks. The main problem was neglecting to explain the rotation.

Question 8

The correct answer was **C**. Since Kylie was at the rear of the carriage she would have been further from Harold than Jason and so would have had to turn her torch on first.

Question 9 to Question 11

Marks	0	1	2	3	4	5	6	7	8	Average
%	25	5	5	11	4	11	8	4	26	**4.06**

Question 9

The answer of **3.2 m** was obtained by dividing the rest distance by the Lorentz factor. The Lorentz factor was given to remove difficulties students might have calculating it. Unfortunately this did not deter many of them from calculating it themselves, with varying degrees of success. There was evidence of confusion as to what the Lorentz factor actually was. Many students had the reciprocal.

Question 10

This was a simple application of time = distance/speed to give an answer of $\mathbf{1.1 x 10^{-5}}$ **s**. The most common error involved confusion over t and t_0.

Question 11

In question 10 students calculated the time of travel in the laboratory reference frame. So according to the electron it would be $t_0 = t/\gamma$ $\mathbf{= 1.1x10^{-8}}$. A common source of error appeared to be confusion over t and t_0.

Detailed study 2 – Investigating structures and materials

Question 1 and Question 2

Marks	0	1	2	3	4	5	Average
%	12	1	27	12	7	42	**3.25**

Question 1

Most students were able to determine the gradient of the line for Young's modulus as $\mathbf{2.0x10^{10}}$

Question 2

Using stress = force/area by substituting the given area of 2 and reading the maximum compressive strength from the graph, the largest force was $\mathbf{4.0x10^{8}}$. The slightly different format of the graph caused some students difficulties. The fact that it contained information on compression and tension caused some to read off the maximum tensile strength instead of compressive strength.

Question 3 to Question 6

Marks	0	1	2	3	4	5	6	7	8	Average
%	14	3	29	5	18	7	14	1	9	**3.47**

Question 3

The strain energy per unit volume was the area under the graph when in compression. It was $\mathbf{1.0x10^{6}}$. Once again some students confused the compressive and tensile sections of the graph and got the area for the wrong section. It was also fairly common for students to calculate a sort of combined area under both sections of the graph.

Question 4

To determine the total strain energy you need to multiply by the volume which was 16. So the answer was **C.**

Question 5

Steel was used because it is strong in tension. This question was generally well answered. However, some students also emphasised that it was strong in compression. While this may be true it was not the reason steel was used as reinforcing in this situation. It is important that students address the actual question asked.

Question 6

The slab was supported on top of the pillar. It would tend to curve down causing tension on the top surface. Therefore reinforcing rods were needed along the top – answer **A**. Most students selected C, presumably because it was what they were used to. There was evidence that some students did not know which slab the question was referring to.

Question 7 to Question 9

Marks	0	1	2	3	4	5	6	7	Average
%	5	3	1	27	0	41	0	22	**4.49**

Question 7

This was a straightforward question which most students did well. The answers were **A, C** and **B** in that order.

Question 8

C is the only option where the upper graph has about twice the maximum stress as the lower graph and they both undergo approximately the same plastic deformation. It also satisfies the condition that the area under the upper curve is about three times the area under the lower curve.

Question 9

Stiffness is related to Young's modulus, which is the gradient of the stress-strain graph. So **B** was the answer. This question was well done.

Question 10 and Question 11

Marks	0	1	2	3	4	5	Average
%	33	7	13	19	23	5	**2.06**

Question 10

The key point was that ice had to be strong in compression. The number of students accessing full marks for this was small and disappointing considering the ease of the question. Many students left this question blank.

Question 11

The arch shape works by transferring forces around through the walls of the igloo. This causes all the blocks of ice to be in compression. The arch is buttressed by the low wall around the base. Very few students obtained full marks. Of those who were awarded some marks very few mentioned the transfer of forces by the arch shape or the buttressing effect of the low outer wall. It was common for students to speak of the arch shape producing compression on the inside and tension on the outside. They were repeating what they knew from other situations but had little idea of the operation of an arch.

Detailed study 3 – Further electronics

Question 1 and Question 2

Marks	0	1	2	3	4	5	Average
%	25	11	26	22	6	11	**2.07**

Question 1

Rectification means converting AC to DC OR making current unidirectional OR a diagram would do. Smoothing means reducing the peak-peak variation in the voltage OR converting pulsing DC into a more even voltage OR a diagram showing this. Voltage regulation means to maintain a constant output voltage even if the load changes. This question was mostly answered well. Poor answers explaining smoothing referred to 'smoothing the output'.

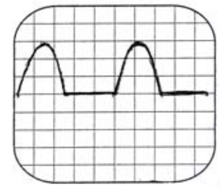
Question 2

The difficulty with this question arose because of the mix of RMS voltage and peak-peak voltage. Students either had to convert 24 $V_{P\text{-}P}$ into ≈ 8.5 V_{RMS} and then 240/8.5 ≈ **28** or convert 240 V_{RMS} to ≈ 679 $V_{P\text{-}P}$ and then 679/24 ≈ **28**

Question 3 to Question 6

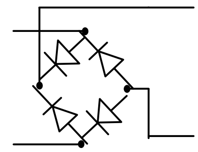
Marks	0	1	2	3	4	5	6	7	8	Average
%	12	0	11	2	18	5	25	2	24	**4.81**

Question 3



The expected answer is shown. Students could lose a mark if the period was incorrect or if the peak voltage was too low or if a horizontal line was included under the pulses. This question was well answered by most students who attempted it.

Question 4



There were numerous ways of drawing this. One is shown here. The majority were able to get full marks, although there were some interesting attempts which did not serve the purpose.

Question 5

Using $\tau = RC$ and substituting in for the time constant and capacitance which were given, the resistance was **1 Ω**.

Question 6

The smaller the time constant the more quickly the voltage will drop so the greater the ripple. **C** is the only option where the time constant is reduced. This was reasonably well answered.

Question 7 and Question 8

Marks	0	1	2	3	4	Average
%	36	3	30	6	25	**1.8**

Question 7

The smoothed voltage to the regulator was about 12 V. The Zener diode and resistor were in series. Since the voltage across the Zener diode was 9 V the resistor got the other **3 V**. Quite a number of students left this question blank. Those who attempted it usually got it correct.

Question 8

D is the best answer as all the other options have errors in them. This question was done well.

Question 9 to Question 12

Marks	0	1	2	3	4	5	6	7	8	Average
%	16	6	20	4	9	7	19	4	15	**3.92**

Question 9

The simplest approach was to use $P = V^2/R$ and substitute in the known voltage and resistance to get **300 mW**. An alternative approach was to use Ohm's law to find the current (0.1 A) and then use $P = VI$. This was generally well done, although quite a number of students omitted it.

Question 10

C is the correct answer. So long as there is sufficient supply voltage the Zener diode determines the output voltage. This was usually answered correctly.

Question 11

The heat sink removes heat so that the components operate properly and are not damaged. It needs to be attached to the regulator. Well answered by the majority.

Question 12

The accepted answer **B** was the most common selected by students. The next most common choice was D.