VCE PHYSICS 2013

YEAR 12 **PRACTICE** EXAM UNIT 3

Reading Time: 15 minutes **Writing Time: 150 minutes**

Structure of Booklet

Section	No of Questions	No of Questions to be answered	No of Marks
A. Core Area of Study			
1. Motion in One and Two Dimensions	29	29	65
2. Electronics and Photonics	23	23	55
B. Detailed Study			
Materials & their Use in Structures	15	15	30
		Total Marks	**150**

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and a scientific calculator. Students are not permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials Supplied

Question and answers booklet with detachable data sheet.

Instructions

Detach the data sheet during reading time.
Write your name in the space provided.
Answer all questions in the question and answers booklet when indicated.
Also show your workings where space is provided.
Where an answer box has a unit printed in it, give your answer in that unit.
All responses must be in English.
Students are not permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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Data Sheet VCE Physics 2013 Year 12 Practice Exam

1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t};\ a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$ $x = \frac{1}{2}(v+u)t$
3	Newton's second law	$F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke's law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}kx^2$
7	gravitational potential energy near the surface of the Earth	mgh
8	kinetic energy	$\frac{1}{2}mv^2$
9	Newton's law of universal gravitation	$F = G\frac{M_1 M_2}{r^2}$
10	Gravitational field	$g = G\frac{M}{r^2}$
11	stress	$\sigma = \frac{F}{A}$
12	strain	$\varepsilon = \frac{\Delta L}{L}$
13	Young's modulus	$E = \frac{\text{stress}}{\text{strain}}$
14	AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak}$ $\quad I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
15	voltage; power	$V = RI$ $\quad P = VI = I^2R = \frac{v^2}{R}$
16	resistors in series	$R_T = R_1 + R_2$
17	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
18	universal gravitational constant	$G = 6.67\times10^{-11}$ N m^2 kg^{-2}
19	mass of Earth	$M_E = 5.98\times10^{24}$ kg
20	radius of Earth	$R_E = 6.37\times10^{6}$ m
21	charge on the electron	$e = -1.6\times10^{-19}$ C

Prefixes / Units

p = pico = 10^{-12}

n = nano = 10^{-9}

μ = micro = 10^{-6}

m = milli = 10^{-3}

k = kilo = 10^{3}

M = mega = 10^{6}

G = giga = 10^{9}

1 tonne = 10^{3} kg

Student Name....………………………...

VCE Physics 2013 Year 12 Trial Exam Unit 3

There are 15 **Multiple Choice Questions** to be answered by circling the correct letter in the table below. Use only a 2B pencil. If you make a mistake, erase it and enter the correct answer. Marks will not be deducted for incorrect answers.

SECTION B: Detailed Study 1 – Materials & their use in Structures

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

VCE Physics 2013 Year 12 Practice Exam Unit 3

SECTION A – Core

Instructions for Section A
Answer all questions for both Areas of Study in this section in the spaces provided.
Where an answer box has a unit printed in it, give your answer in that unit.
You should take the value of g to be 10 m s–2.
In questions where more than one mark is available, appropriate working should be shown.

Areas of Study

Area of Study 1 – Motion in One and Two Dimensions

Questions 1 - 3 refer to the following information.

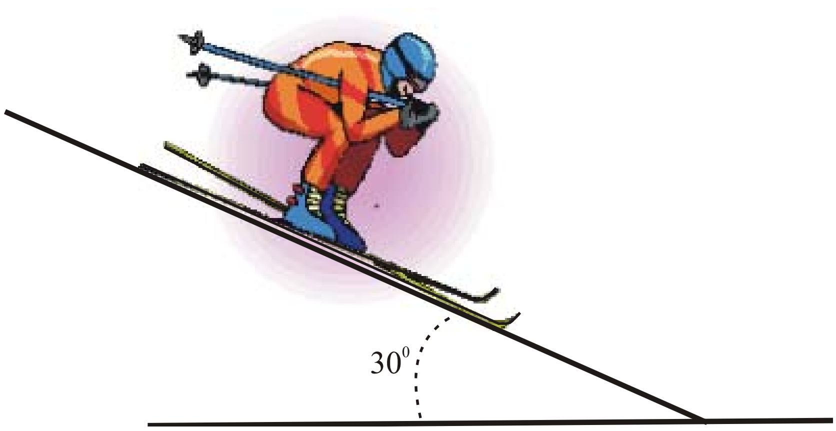

Figure 1

Tony has a mass of 70 kg and has just begun descending a 30° slope as shown in **Figure 1.** The magnitude of his acceleration down the slope is 4.0 m s^{-2}.

Question 1

Calculate the magnitude of the constant resistance force opposing Tony's motion down the slope.

N

(3 marks)

Question 2
Calculate Tony's speed down the slope after 6.0 s.

m s^{-1}

(2 marks)

After 6 seconds, Tony runs onto some soft snow and comes to rest over a distance of 45 m.

Question 3
Calculate the magnitude of the average retarding force, in N, that brings Tony to rest.

N

(2 marks)

Figure 2 shows a mass of 0.10 kg that is attached to a hanging mass of 0.90 kg by a cord. The table is frictionless and the small mass rotates in a circular path.

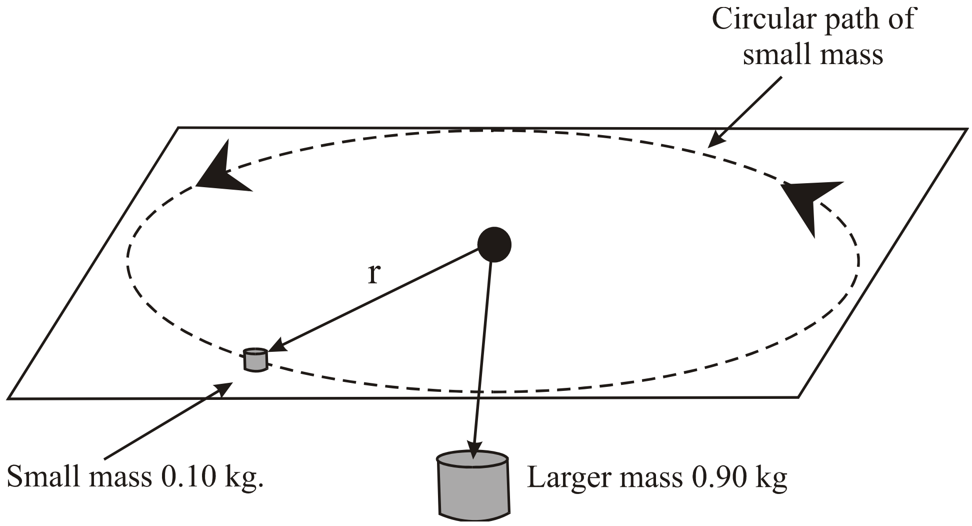

Figure 2

Question 4
Calculate the speed of rotation, in m s^{-1}, of the 0.10 kg mass which will keep the 0.90 kg mass at rest, if the radius of rotation, *r*, is 0.80 m.

m s^{-1}

(2 marks)

Eric stands motionless on a set of bathroom scales and notes the reading as 300 N. He then crouches down and suddenly jumps up. Jason, who is watching, notes that the reading on the bathroom scales momentarily increases to 400 N when Eric jumps up.

Question 5
Calculate the magnitude of Eric's maximum acceleration as he jumps up.

m s^{-2}

(3 marks)

Questions 6 - 8 refer to the following information.

Figure 3 shows a train with an engine, a coal truck and carriage travelling at constant velocity along a straight, horizontal section of track. The mass of the engine is 20.0 tonnes and the mass of each of the carriages is 10.0 tonnes.

At this constant velocity the resistance force (due to frictional forces and air resistance) on the engine is 2000 N and the carriage and coal truck experience a resistance force of 1500 N each.

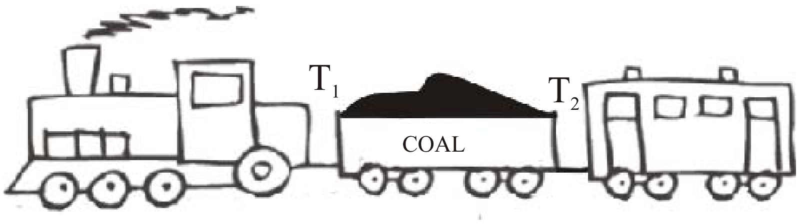

Figure 3

Question 6

Calculate the magnitude of the driving force provided by the engine.

N

(2 marks)

While still on the same section of track, the train is required to speed up and so the engine driving force is increased to 2.5×10^4 N.

Question 7

Calculate the acceleration of the train during this process. Assume that the resistance forces have not changed.

m s $^{-2}$

(2 marks)

During another part of the journey, the train is accelerating at 0.20 m s^{-2} along a straight, level section of track.

Question 8

Calculate the magnitude of the tension (T_1) in the coupling between the engine and the coal truck during this acceleration. (Assume that the resistance forces remain the same as before).

N

(3 marks)

Questions 9 - 11 refer to the following information.

The shot put is a field event at the Commonwealth Games involving "putting" (throwing in a pushing motion) a heavy metal ball as far as possible. Competitors must rest the shot in between the neck and shoulder and keep it tight to the neck while throwing. At the end of the throw, the thrower must push the throwing arm straight with the thumb pointing down (to avoid injury).

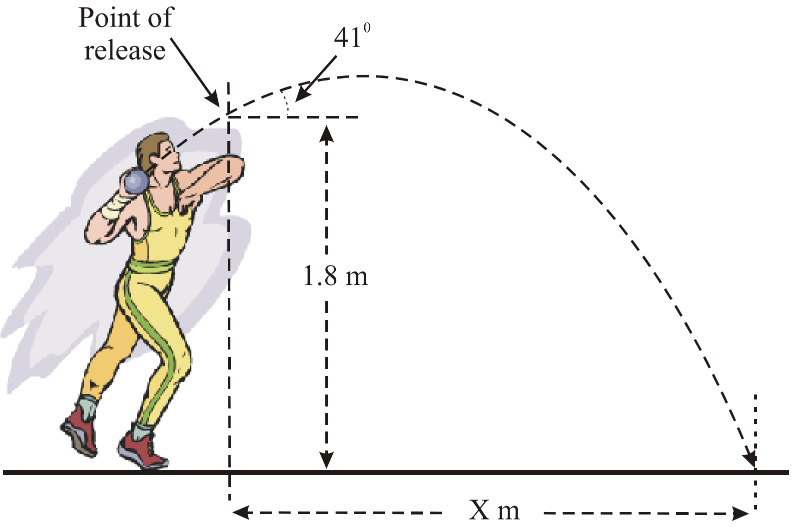

Figure 4

One competitor releases the shot from a vertical height of 1.8 m at an angle of 41° to the horizontal as shown in **Figure 4**.

Question 9

If the time of flight from release of the shot to impact with the ground is 2.1 s, calculate the speed of the shot on release from the competitor's hand. (Ignore the effects of air friction). Take g = 10 m s^{-2}.

$m\ s^{-1}$

(3 marks)

Question 10

Calculate the horizontal distance, X m, moved by the shot after the release.

m

(2 marks)

The world record distance for the men's shot put is close to 23 m.

Question 11

Compare your result in question 10 with this world record value.

____

____

____

(1 mark)

Questions 12 - 16 refer to the following information.

A piston is attached to a spring placed in a semi-circular horizontal tube of diameter 0.80 m as shown in **Figure 5**. A ball of mass 0.060 kg at rest is placed against the plunger that has been pulled back a distance of 0.050 m and fires the ball around the tube. Ignore friction when answering these questions.

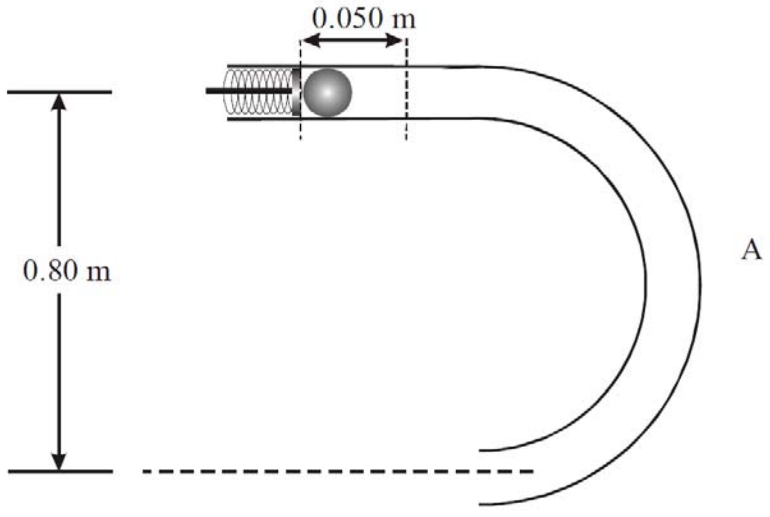

Figure 5

The spring characteristics are shown in **Figure 6**.

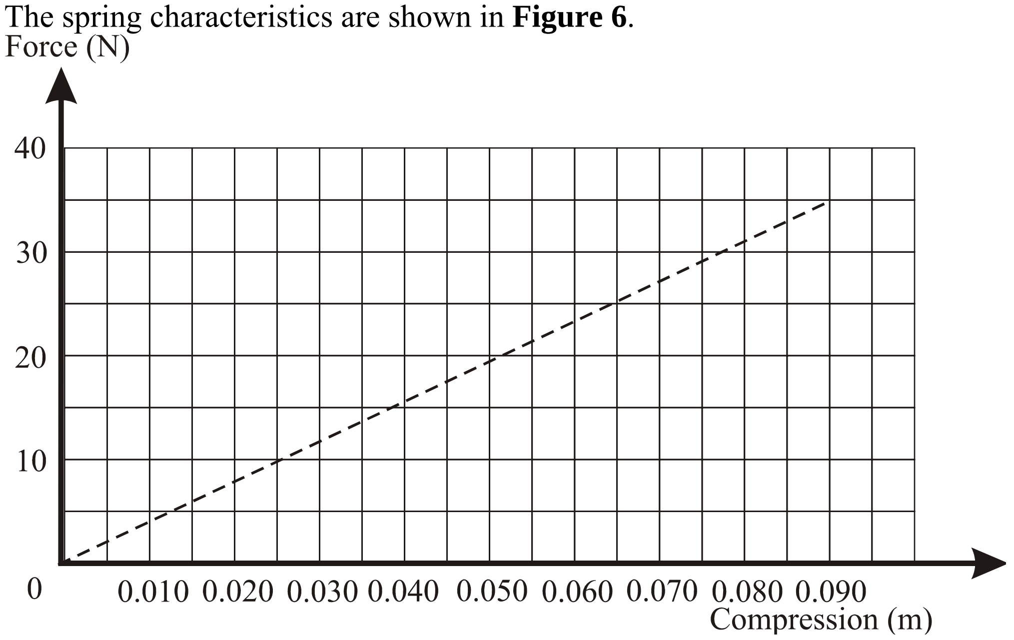

Figure 6

Question 12
Calculate the value of the spring constant.

N m^{-1}

(2 marks)

Question 13
Calculate the amount of energy, in joule, stored in the spring when it is compressed by 0.050 m.

J

(2 marks)

When the spring is compressed by 0.050 m and piston released, the ball is forced to move around the semi - circular tube. 80% of the energy stored in the spring is transferred to the ball.

Question 14
Calculate the speed of the ball as it loses contact with the piston.

m s^{-1}

(3 marks)

Question 15
Determine the speed at which the ball is travelling as it passes through point A in **Figure 7**.

m s^{-1}

(1 mark)

Question 16
Calculate the magnitude of the centripetal force acting on the ball at point A in **Figure 7**.

N

(2 marks)

Questions 17 - 19 refer to the following information.
In a braking test a car was travelling down a smooth straight road with an incline of 1 in 10 as shown in **Figure 7**. The total mass of the car and driver was 1000 kg.
The initial speed of the car was 30 m s $^{-1}$ when a constant braking force was applied. The car travelled a distance of 100 m down the incline before stopping.

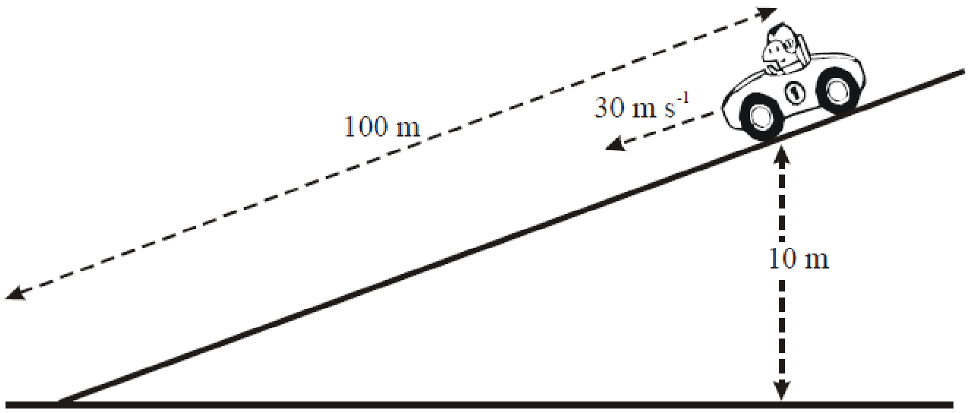

Figure 7

Question 17
Calculate the kinetic energy of the car and driver just before the brakes were applied.

J

(2 marks)

Question 18
Calculate the change in gravitational potential energy of the car and driver from the time the brakes were applied to the time the car stopped.

J

(2 marks)

Question 19
Calculate the magnitude of the constant braking force applied to the car.

N

(3 marks)

Questions 20 - 21 refer to the following information.

Figure 8

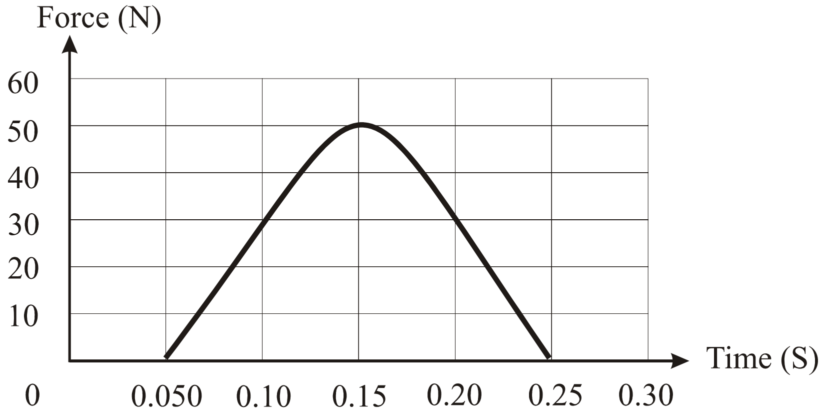

Figure 9

Anne throws a volleyball of mass 0.20 kg vertically into the air to serve. She strikes the ball with her hand at the instant the ball is motionless in the air. The force exerted by her hand on the ball varies with time as shown in **Figure 9**.

Question 20
Estimate the impulse of the force exerted by Anne's hand on the ball.

N s

(2 marks)

Question 21
Calculate the speed of the ball immediately after impact with Anne's hand.

m s^{-1}

(2 marks)

Questions 22 - 23 refer to the following information.
A cue ball of mass 0.20 kg travelling with a speed of 3.0 m s^{-1} collides with a stationary snooker ball of mass 0.25 kg and imparts a speed of 1.8 m s^{-1} to the snooker ball. The snooker ball moves in the same direction as the incoming cue ball after collision.

Question 22
Calculate the speed of the cue ball after collision.

m s^{-1}

(3 marks)

Question 23
Use a calculation to show whether the collision was elastic or inelastic. State your conclusion clearly.

The collision was

(4 marks)

Questions 24 - 25 refer to the following information.

Figure 10 shows how the gravitational field strength of the Earth varies with distance from the Earth's centre over a limited domain.

A satellite of mass 300 kg in a circular orbit around the Earth has a radius of orbit, as measured from the Earth's centre, of 1.4×10^7 m. The period of the satellite is 4.6 hours.

Question 24

Calculate the speed, in m s $^{-1}$, of the satellite in the orbit of this radius.

m s^{-1}

(2 marks)

The satellite is now moved to an orbit nearer the Earth of radius 1.0×10^7 m.

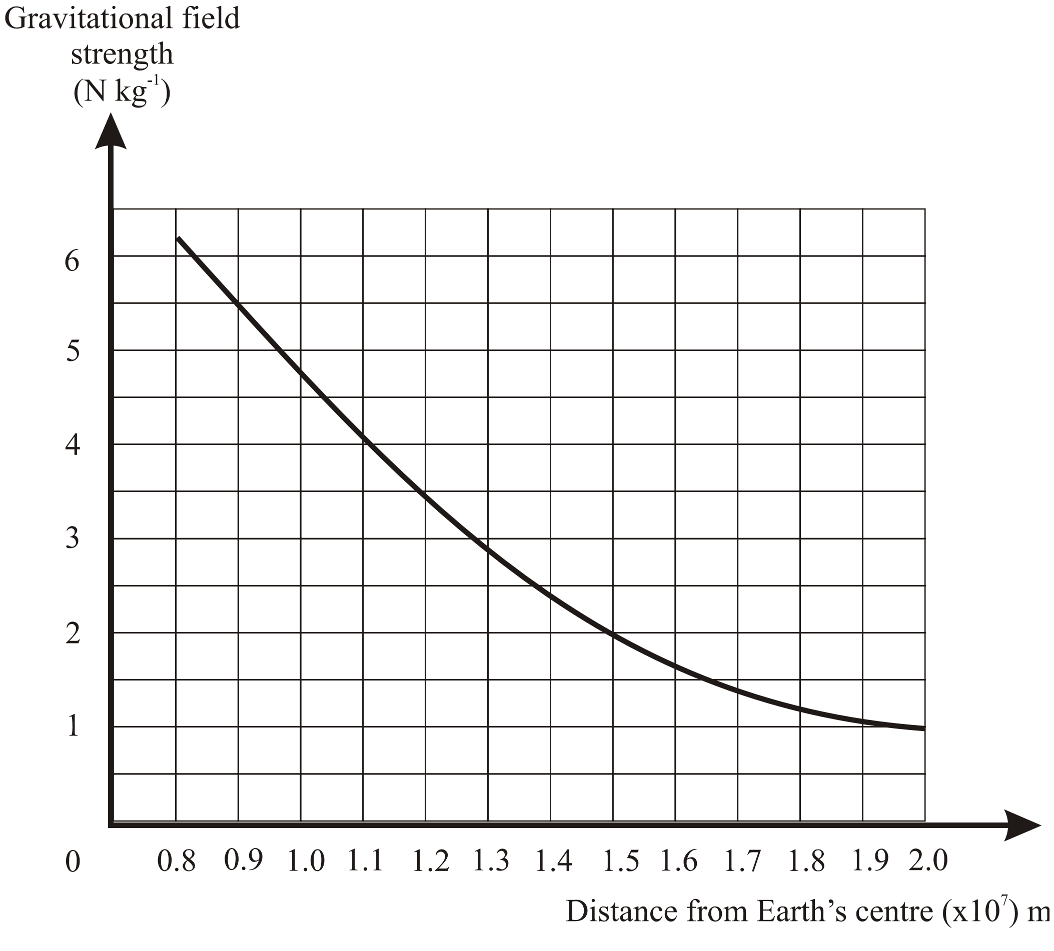

Figure 10

Question 25
Estimate the magnitude of the change in potential energy of the satellite and state whether the change in potential energy is an increase or a decrease.

J

(3 marks)

Questions 26 - 29 refer to the following information.

One of the more than 200 extra-solar planets discovered recently revolves in a circular path around a star, (HR 7291, found in the constellation Sagittarius), at a distance of 7.7×10^9 m (between centres). The period for the rotation of the planet is 3.09 days.

Question 26
Calculate the orbital velocity, in m s^{-1}, of the planet.

m s^{-1}

(2 marks)

Question 27
Calculate the mass, in kg, of the parent star.

kg

(2 marks)

The mass of the planet revolving around star HR 7291 is 1.6×10^{26}.

Question 28

Calculate the magnitude of the gravitational force of attraction between the planet and star HR 7291.

N

(2 marks)

Question 29

How would the surface temperature of this planet compare with that of the Earth's surface temperature?

____

(1 mark)

End of Area of Study 1

Area of Study 2 – Electronics and Photonics

Questions 1 - 2 refer to the following information.
Figure 1 shows several 12 V, 21W lamps connected in parallel. The circuit is protected by a fuse that melts if the current in the circuit exceeds 10A.

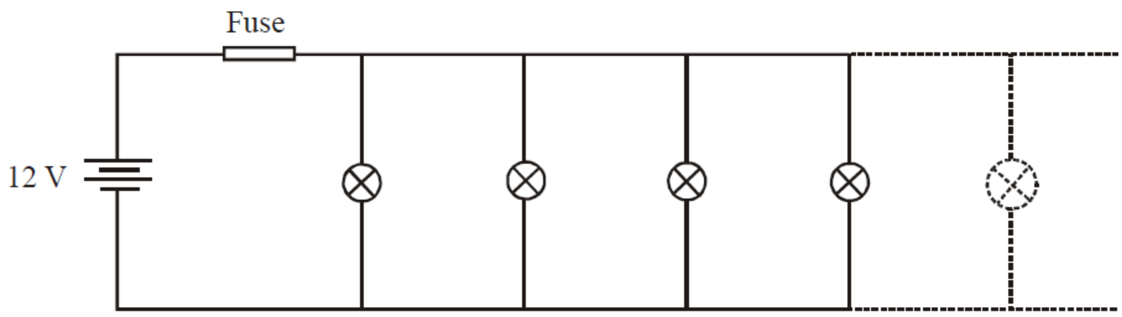

Figure 1

Question 1
Determine the maximum number, of lamps (*n*) that can be used without melting the fuse.

n=

(2 marks)

Question 2
Calculate the working resistance of a single 12 V, 21W lamp.

ohm

(2 marks)

Question 3 refers to the following information.

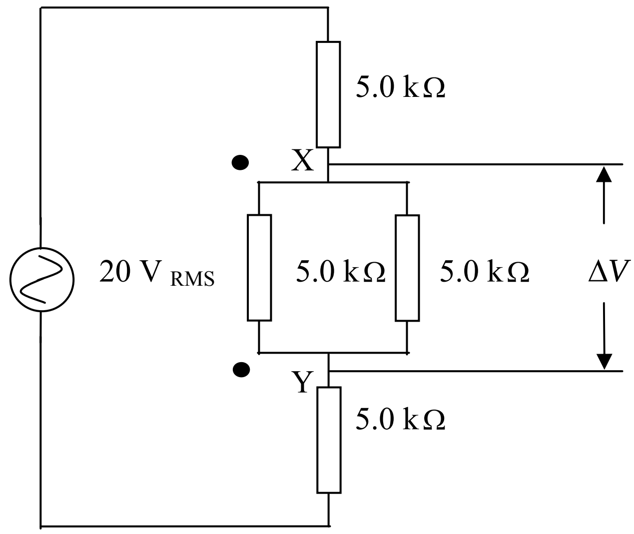

Figure 2

In **Figure 2**, four identical 5.0 kΩ resistors are used to construct a voltage divider. The voltage source across this voltage divider is an AC supply with an RMS voltage of 20 V.

Question 3

Calculate the RMS potential difference, ΔV, across points X and Y.

V

(3 marks)

Questions 4 – 5 refer to the following information.
A shop security circuit consists of a narrow beam of light that shines onto a Light Dependent Resistor that is part of a voltage divider circuit as shown in **Figure 3**.
R_1 is a variable resistor and its resistance can be varied between 0 and 2.0 kΩ. The resistance of the Light Dependent Resistor, R_2, varies as lighting conditions vary and the characteristics of the Light Dependent Resistor are shown in **Figure 4**.

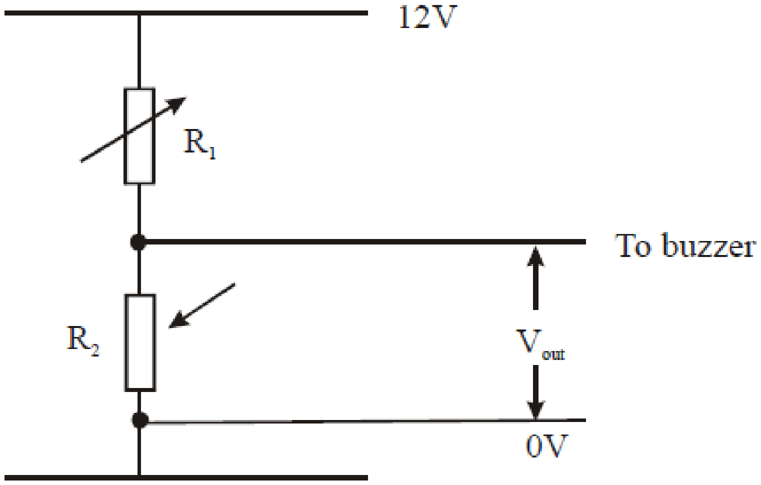

Figure 3

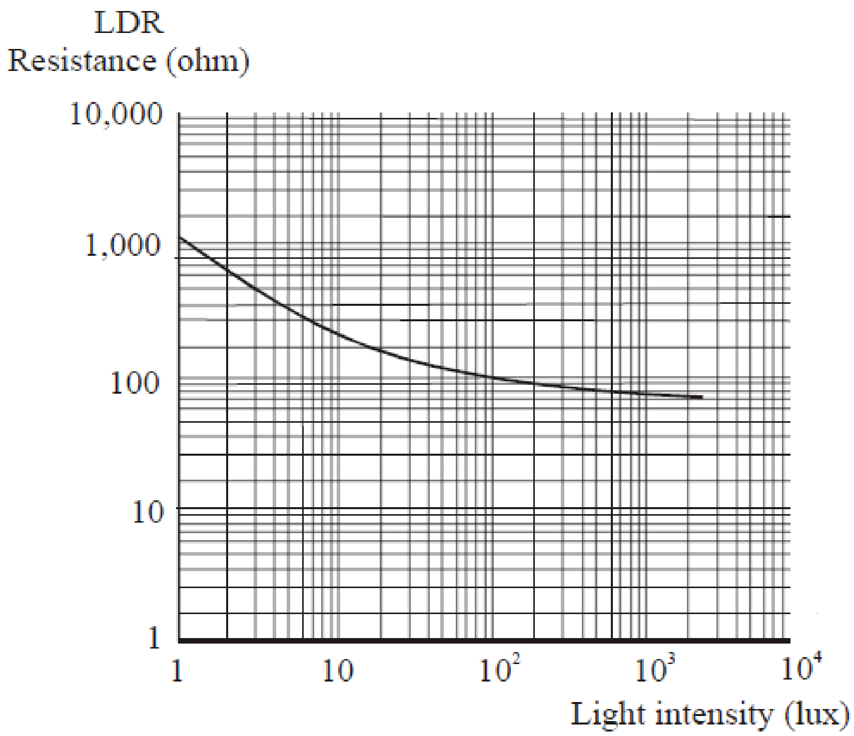

Figure 4

The variable resistor is set at 400 Ω.

Question 4

Calculate the value of V_{out} in **Figure 3** when the light intensity is 100 lux.

V

(3 marks)

Question 5

Calculate the value of the resistance of the variable resistor, (in kΩ), if the light intensity is 1.0 lux and the value of V_{out} is 5.0 V.

kΩ

(3 marks)

Questions 6 - 7 refer to the following information.
The circuit shown in **Figure 5** consists of a fixed resistor, R, and a thermistor which can be used to activate a light emitting diode whenever the temperature rises above a certain level. **Figure 6** shows the thermistor temperature – resistance characteristics.

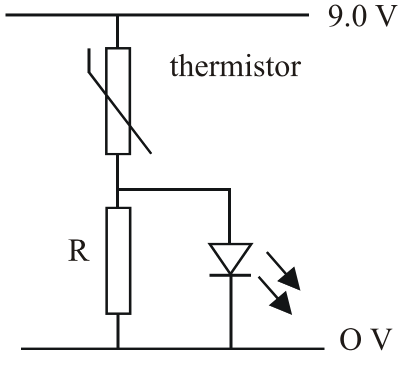

Figure 5

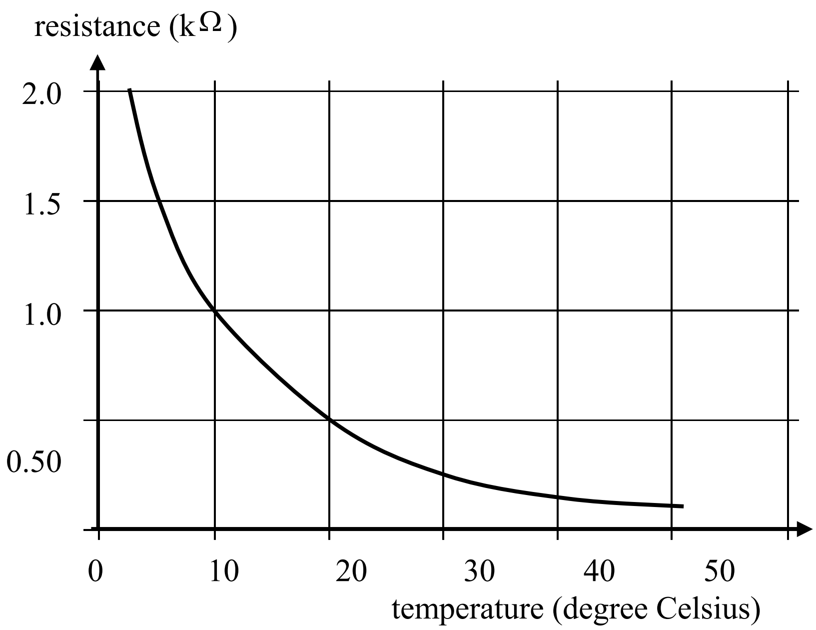

Figure 6

When the temperature is 20^{0}C, the potential difference across the LED is 2.2 V and the current flowing through it is 10 mA.

Question 6

Calculate the magnitude of the resistance of resistor R.

Ω

(4 marks)

The LED switches on when there is a potential difference of 2.0 V across it. The current flowing in the LED is 3.7 mA.

Question 7

Calculate the lowest temperature at which the LED will switch on.

^{0}C

(3 marks)

Questions 8 - 11 refer to the following information.

Figure 7 shows a circuit that can be used to sense temperature changes. Sensing is possible because the potential difference across the thermistor changes as the temperature changes.

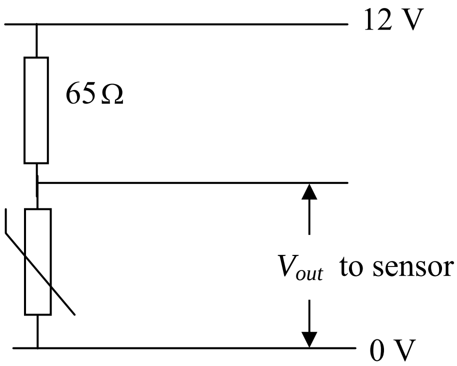

Figure 7

At a high temperature, the potential difference across the thermistor is 4.5 V.

Question 8

Calculate the current in the circuit when the temperature is high.

A

(2 marks)

The temperature now changes to 25°C and the resistance of the thermistor becomes 350 Ω.

Question 9

Calculate the potential difference across the thermistor, V_{out}, when the temperature is 25°C.

V

(2 marks)

Question 10
Calculate the power, in mW, dissipated in the 65 Ω resistor when the temperature is 25°C.

mW

(2 marks)

The circuit is modified as shown in **Figure 8**. A resistor of resistance 570 Ω is connected in parallel with the thermistor.

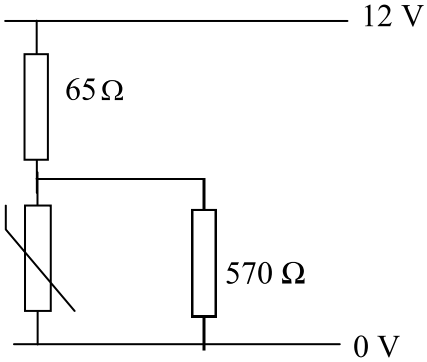

Figure 8

Question 11
For the circuit in **Figure 8,** calculate the current, in mA, in the 65 Ω resistor when the temperature is 25°C.

mA

(3 marks)

Question 12
Describe three advantages of LED's over ordinary filament light globes.

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(3 marks)

Questions 13 – 16 refer to the following information.
Figure 9 shows the current-voltage characteristics for a particular LED. The circuit shown in **Figure 10** consists of an LED connected in series with a 250 Ω resistor. The current in the circuit is 60 mA and the LED glows brightly.

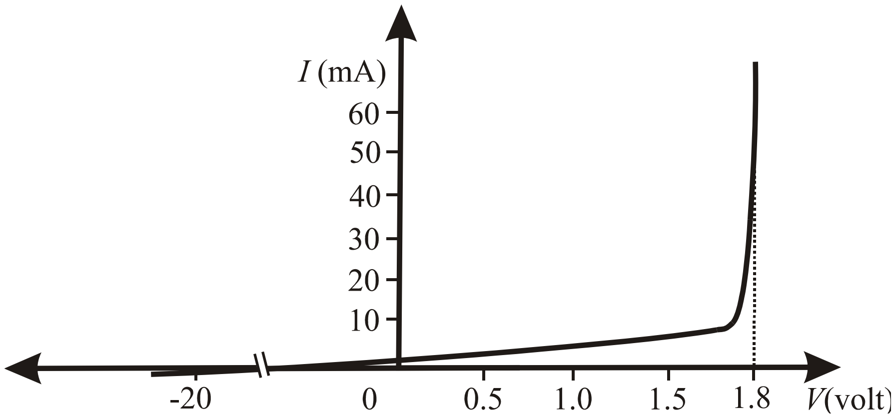

Figure 9

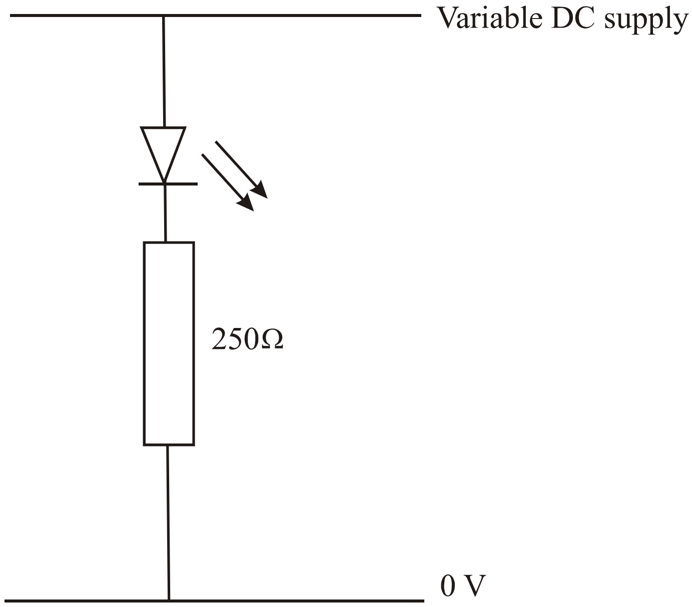

Figure 10

Question 13
Calculate the voltage drop across the 250 Ω resistor.

V

(2 marks)

Question 14
Calculate the emf of the supply.

V

(2 marks)

The LED connection in the circuit is now reversed and the input voltage is adjusted to 20 V.
Question 15
Determine the current flowing in the circuit. Justify your answer.

(2 marks)

The LED is again correctly biased and the power supply is changed back to its original value.
A total current of 60 mA flows in the circuit.
A 500 resistor is now connected in parallel with the LED, which continues to glow brightly.
Question 16
Calculate the current, in mA, flowing through the 500 Ω resistor.

mA

(2 marks)

The following information relates to Questions 17 and 18.

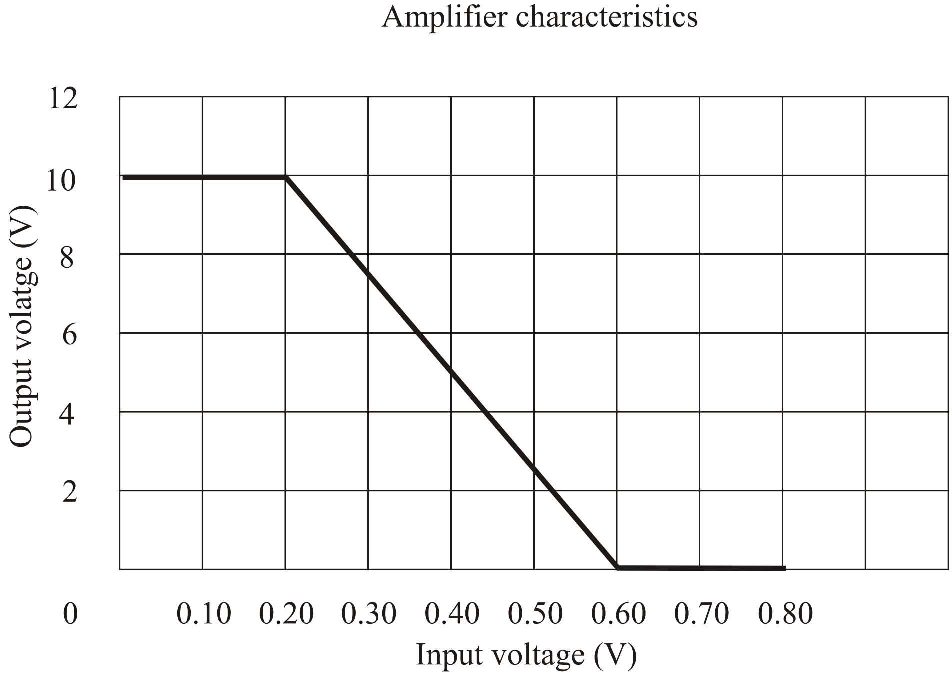

Figure 11

Question 17
Calculate the gain of this amplifier.

(2 marks)

Question 18
Is this an inverting or non-inverting amplifier?

(2 marks)

The following information relates to Questions 19 and 20.
A hair dryer has three settings, high, medium and low. These are obtained by connecting the three heating elements in parallel or in series across a 240 V mains supply. When the three elements are connected in series, the total power dissipated is 480W.

Question 19
Assuming each element has the same resistance, find the resistance of the elements when they are connected in series.

Ω

(2 marks)

Question 20
When the three elements are now connected in parallel, find the total resistance of the circuit.

Ω

(2 marks)

Question 21
Explain the difference between a non ohmic and an ohmic device.

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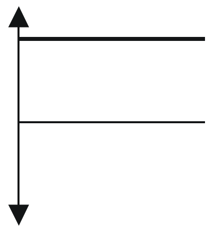
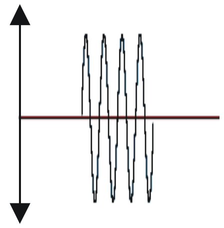
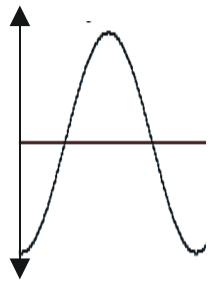
___

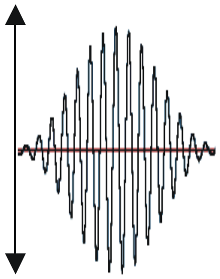
(2 marks)

Question 22
Which one of the following waveforms best shows the intensity modulated carrier wave?

A.


B.


C.


D.


(2 marks)

Demodulation in an optical system is achieved by a transducer known as a detector.

Question 23
Name one common detector and describe its operation in the demodulation process.

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____

____

(3 marks)

End of Area of Study 2

End of Section A

VCE Physics 2013 Year 12 Practice Exam Unit 3

SECTION B – Detailed Study

Instructions for Section B
Answer all questions from the Detailed Study, in pencil, on the answer sheet provided for multiple-choice questions.
Choose the response that is correct for the question.
A correct answer scores 2, an incorrect answer scores 0.
Marks will not be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
You should take the value of g to be 10 m s^{-2}.
Unless indicated, diagrams are not to scale.

Detailed Study 3.3 – Materials and their Use in Structures

Figure 1 shows a material under three different types of stress.

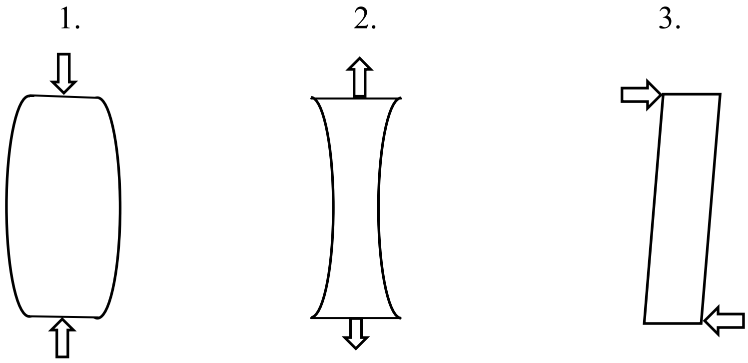


Figure 1

Question 1
The type of stress shown in order from 1 – 3 in **Figure 1** is
A. compression; shear; tension.
B. compression; tension; shear.
C. shear; tension; compression.
D. compression; tension; strain.

A force is used to rotate a beam in an anticlockwise direction. As the beam rotates from position 1 to position 4, as shown in **Figure 2**, the direction of the force changes as shown, but its magnitude remains constant.

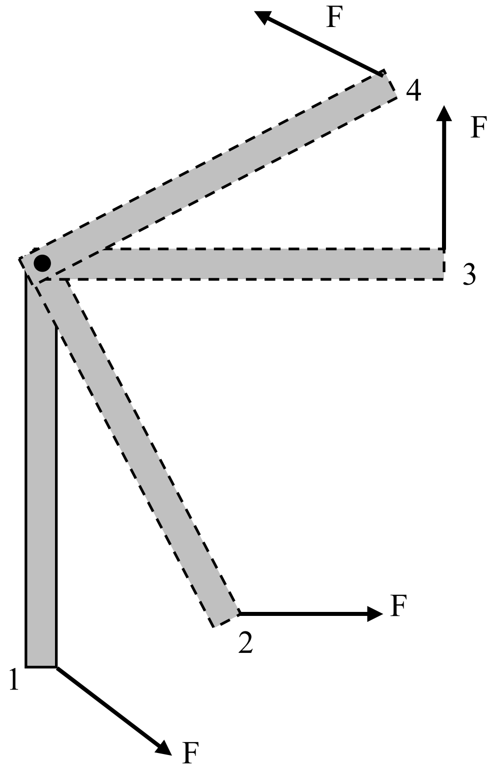


Figure 2

Question 2

From alternatives A – D, choose the one that describes how the magnitude of the torque of the force changes as the beam rotates from position 1 to position 4.

A. The torque is always increasing.
B. The torque is always decreasing.
C. The torque increases then decreases.
D. The torque decreases then increases.

Question 3

Which one of the following means that copper has a tensile strength of 2.5×10^{8} N m^{-2}?

A. A sample of copper will probably break if subjected to a stress of 2.5×10^{8} N m^{-2}.
B. A sample of copper will become permanently deformed if subjected to a stress greater than 2.5×10^{8} N m^{-2}.
C. Copper is not as strong as Hooke's Law.
D. A sample of copper will break if subjected to a force of 2.5×10^{8} N.

Athletes quite often suffer from Achilles tendon problems when too great a stress, *T*, is placed on the tendon. **Figure 3** models a situation when a person stands on tiptoe.
(x = 6.0 cm and y = 18 cm and A is the ankle joint).

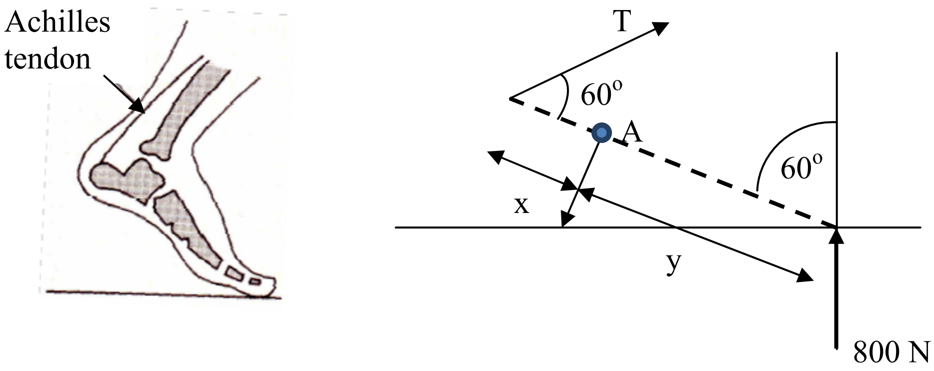


Figure 3

In one situation, the reaction force on the athlete's foot is 800 N, as shown in **Figure 3**.

Question 4

The tension force in the Achilles tendon is calculated to be

A. 1.4×10^3 N
B. 1.6×10^3 N
C. 2.4×10^3 N
D. 4.2×10^3 N

Questions 5 - 8 refer to the following information.
The graph shown in **Figure 4** is the stress – strain curve for a horse's leg bone.
The bone sample tested had a cross-sectional area of 3.5 x 10^{-4} m^2.

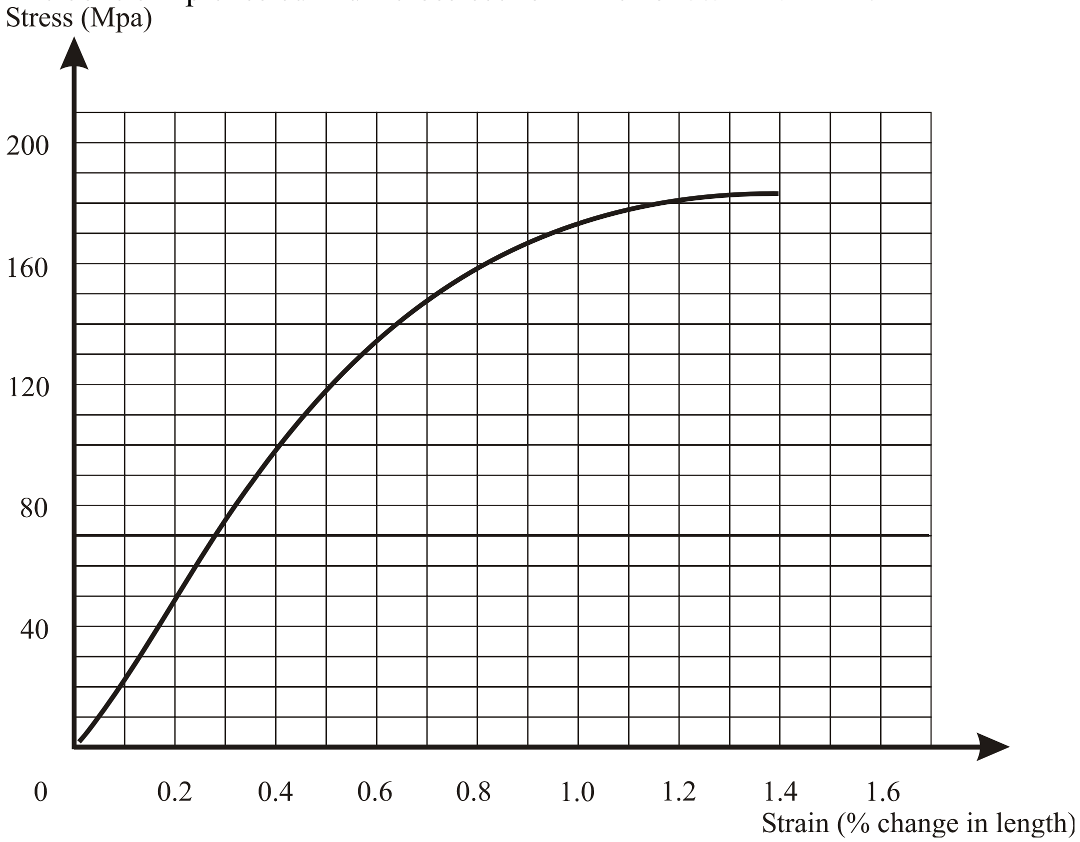


Figure 4

The leg bone of a galloping horse may experience stresses up to 60 MPa. The original length of the leg bone is 40.0 cm.

Question 5
The length of the bone affected by a stress of 60 MPa would be
A. 28.0 cm
B. 38.8 cm
C. 39.9 cm
D. 40.1 cm

Question 6
The value of Young's modulus for the bone under analysis is
A. 25 x 10^4 Nm^{-2}
B. 2.5 x 10^6 Nm^{-2}
C. 2.5 x 10^8 Nm^{-2}
D. 2.5 x 10^{10} Nm^{-2}

The sample of bone is now subjected to a stress of 100 MPa.

Question 7

When calculated, the stored energy in the bone due to this stress of 100 MPa is

A. 2.0×10^5 J
B. 2.5×10^5 J
C. 2.0×10^7 J
D. 2.5×10^7 J

Question 8

Which one of the following values (A – D) is the best estimate for the elastic limit of the bone?

A. 40 MPa
B. 100 MPa
C. 150 MPa
D. 185 MPa

Questions 9 - 10 refer to the following information. Use the letters A – D to answer each question.

Four different materials, A – D, are tested and their stress versus strain characteristics are shown on the same set of axes in **Figure 5**. Each fracture point is denoted by 'X'.

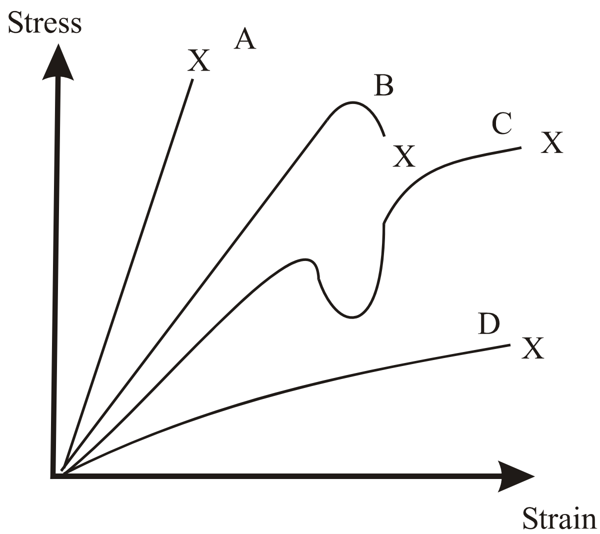


Figure 5

Question 9

The most brittle material is

A. A
B. B
C. C
D. D

Question 10
The toughest material is
A. A
B. B
C. C
D. D

Questions 11 - 12 refer to the following information.
A simple bridge of mass 1.8 tonne and uniform length 12 m is supported at both ends, A and B. There is a truck of mass 4.5 tonne parked at a distance of 3.0 m from end A of the bridge, as shown in **Figure 6.**

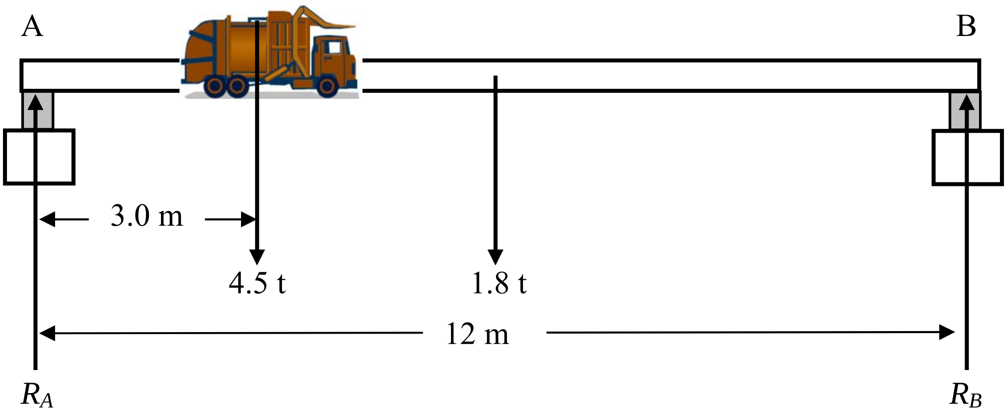


Figure 6

Question 11
Which one of the following best gives the magnitude of the force, in N, on the bridge by the support at point B?
A. 1.4×10^5 N
B. 2.0×10^4 N
C. 1.4×10^4 N
D. 3.2×10^3 N

Question 12
Which one of the following best gives the magnitude of the force, in N, on the bridge by the support at point A?
A. 4.3×10^4 N
B. 2.9×10^4 N
C. 3.2×10^3 N
D. 4.3×10^5 N

Figure 7 shows a car park barrier of uniform length 4.0 m, and weight, *W*, balanced in a horizontal position by a 500 N counterweight placed a distance of 0.60 m from the pivot.

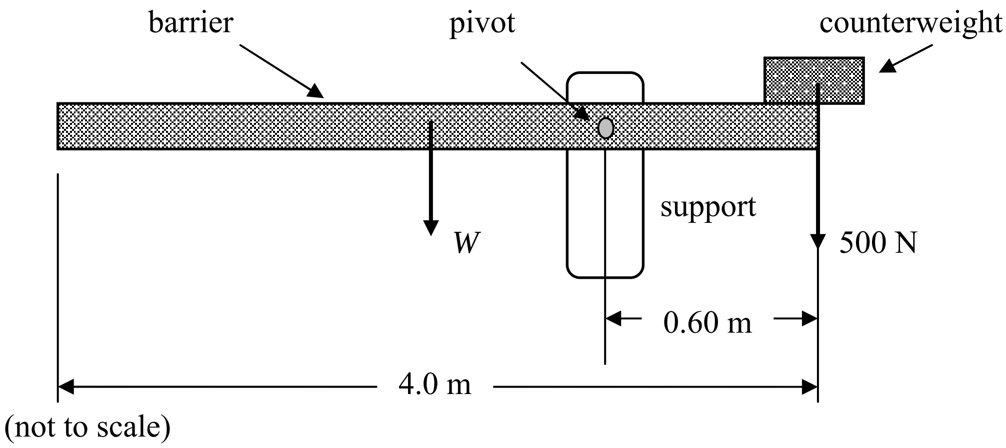


Figure 7

Question 13
The mass, in kg, of the barrier shown in **Figure 7** is

A. 214
B. 21
C. 15
D. 88

Figure 8 shows a screwdriver being used to prise open a tin of paint. The end of the screwdriver is placed under the lip of the lid and the handle is pushed down. The resistance force of the lid is 400 N.

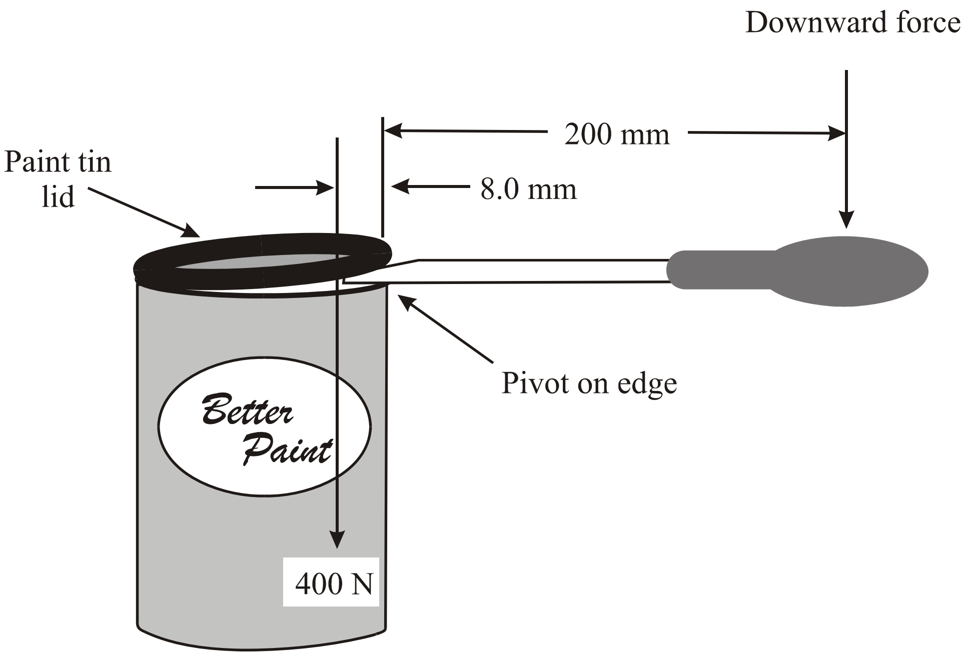
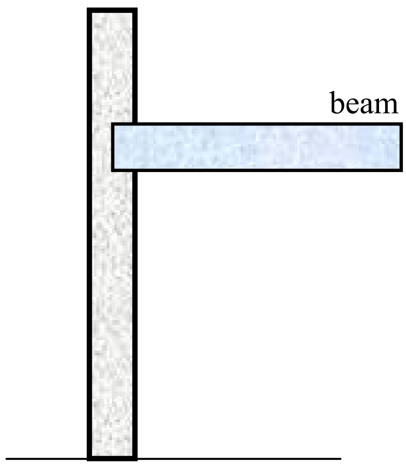


Figure 8

Question 14
The minimum downward force required to just lever off the lid in **Figure 8** is
A. 16 N
B. 400 N
C. 21 N
D. 416 N

To help overcome its poor tensile strength, concrete is often reinforced with steel rods. The steel, which has high tensile strength, is placed in the concrete at a location where the tensile stresses will be at a maximum. Four different positions for steel rod reinforcing are shown in **Figure 9**.



a cantilever

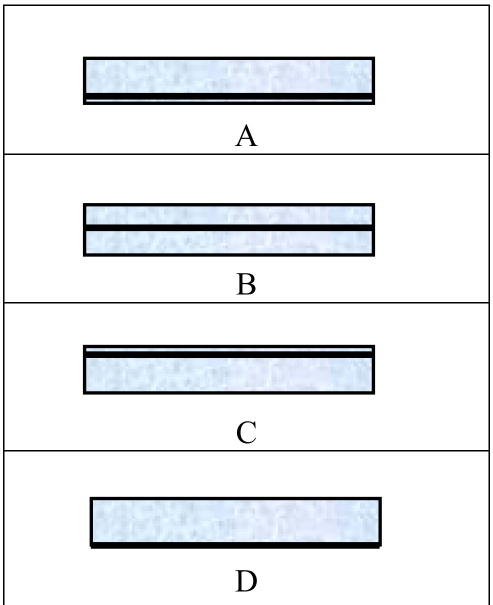


Figure 9

Question 15
The alternative from A – D in **Figure 9** that best shows where steel rod reinforcing should be placed in the beam is
A. option A.
B. option B.
C. option C.
D. option D.

End of Practice Exam

Suggested Answers

VCE Physics 2013 Year 12 Practice Exam Unit 3

SECTION A – Core

Question	Area of Study 1 – Motion in One and Two Dimensions	Mark Allocation
1.	Resolving forces along the plane; $mg\sin 30^0 - F_R = ma$ $F = mg\sin 30^0 - ma$ $= (70\times10\times0.50) - (70\times4.0)$ $= 350 - 280$ N $= 70$ N	1 1 1
2.	Use; $v = u + at$ $v = 4.0\times6.0$ m s^{-1} $v = 24$ m s^{-1}	1 1
3.	Work done to stop = loss in kinetic energy $F\times x = \frac{1}{2}mv^2$ $F = \frac{mv^2}{2x}$ $= \frac{70\times24^2}{2\times45}$ $= 448$ N $= 4.5\times10^2$ N	1 1
4.	Use: The tension in the string that is created by the circular motion must equal the weight of the larger mass. $\frac{mv^2}{r} = Mg$ $v^2 = \frac{Mgr}{m}$ $v = \sqrt{\frac{0.90\times10\times0.80}{0.10}}$ $v = 8.5$ ms^{-1}	1 1

5.	Use: Eric has a mass of 30 kg. $F_{net} = 400 - 300$ N $= 100$ N $a = \frac{F}{m}$ $a = \frac{100}{30}$ $= 3.3$ ms^{-2}	1 1 1
6.	Since the train is moving with a constant velocity, the horizontal net force is zero. $F_{DRIVING\ FORCE} + \sum F_{RESISTANCE\ FORCES} = 0$ $F_{DRIVING\ FORCE} = 2000 + 1500 + 1500$ $= 5000$ N $= 5.0 \times 10^3$ N	1 1
7.	To calculate the acceleration of the train; Consider the system as a whole; Total mass of the system: 40 tonnes $2.5 \times 10^4 - 5000 = 2.0 \times 10^3$ N $a = \frac{F}{m}$ $= \frac{2.0 \times 10^3}{40000}$ $= 0.50$ ms^{-2}	1 1
8.	$\sum F_T = ma$ Consider the forces on the carriage: $T_2 - 1500 = 10000 \times 0.20$ $\therefore T_2 = 3500$ N Consider the forces on the coal truck: $\sum F_{CT} = ma$ $T - 3500 - 1500 = 10000 \times 0.20$ $\therefore T_1 = 7000$ N $=7.0 \times 10^3$N	1 1 1

9.	Consider the vertical components of the motion: $-u_v$ = is the vertical component of the initial speed. -u = release velocity $-u_v = u\sin 41°$ t = 2.1 s x = 1.8 m g = 10 ms^{-1} *Use* : $x = ut + \frac{1}{2}at^2$ i.e. $x = ut + \frac{1}{2}at^2$ $x = -usin41°t + \frac{1}{2}gt^2$ $1.8 = (-2.1 \times 0.656u) + (0.5 \times 10 \times 2.1^2)$ $1.8 = -1.38u + 22.05$ $u = \frac{20.25}{1.38}\ ms^{-1} = 14.7\ ms^{-1}$ *Answer* : release speed. u = 15 ms^{-1}	 1 1 1
10.	The horizontal displacement is; $x = ucos41° \times t$ $x = (14.7 \times 0.755) \times 2.1$ x = 23.3 m Answer: Horizontal displacement = 23m	 1 1
11.	This value obtained (23m) is very close to the world record. The release speed of the shot and the angle of release would be close to optimum values for maximum range.	1
12.	The force constant of the spring, k, is the gradient of the graph. $k = \frac{20}{0.05}$ $= 400\ Nm^{-1}$ $= 4.0 \times 10^2\ Nm^{-1}$	2
13.	The stored energy in the spring is numerically equal to the area under the graph between the compression limits. $U_s = \frac{1}{2}(20)(0.05)\ J = 0.50\ J$ or $U_s = \frac{1}{2}kx^2 = \frac{1}{2} \times 400 \times (0.050)^2 = 0.50\ J$	2

14.	80% of the stored energy is converted into kinetic energy of the ball. 80% of U_s lost = kinetic energy gained by the ball $0.80 \times 0.50 = \frac{1}{2}(0.06)(v^2)$ $v^2 = 13.3$ $v = 3.7\ ms^{-1}$	1 2
15.	Since there is negligible friction between the ball and tube, the speed of the ball will remain constant. Answer: $3.7\ m\ s^{-1}$	1
16.	Use $F_c = \frac{mv^2}{r}$ $= \frac{(0.06)(13.3)}{0.40}$ $= 2.0\ N$	2
17.	To calculate the instantaneous kinetic energy of the car and driver; $E_k = \frac{1}{2}mv^2$ $= (0.5 \times 1000 \times 30^2)$ $= 4.5 \times 10^5\ J$	2
18.	Use: $\Delta U_g = mg\Delta h$ $=(1000 \times 10 \times 10)$ $=1.0 \times 10^5\ J$	2
19.	Work done by the brakes to stop the car and driver will equal the loss in U_g and the loss in the original E_k $F \times x = \Delta U_g + \Delta E_K$ $F \times 100 = (1.0 \times 10^5) + (4.5 \times 10^5)$ $F = \frac{5.5 \times 10^5}{100}$ $= 5.5 \times 10^3\ N$	2 1
20.	The area under the graph of Force versus time is numerically equal to the magnitude of the impulse of the force. 1 grid square = 0.50 Ns Counting squares ≈11.5 Area ≈ 11.5 × 0.50 ≈5.8 Ns	1 1

21.	Using the previous answer: $F\Delta t = m\Delta v$ $5.8 = 0.20(v-0)$ $v = \frac{5.8}{0.20}$ $v = 29\text{ ms}^{-1}$	1 1
22.	$\sum p_i = (0.20\times 3.0)+0$ $\sum p_f = (0.20\times v)+(0.25\times 1.8)$ $\sum p_i = \sum p_f$ $0.2v = 0.60-0.45$ $v = 0.75\text{ ms}^{-1}$	1 2
23.	$\sum E_{Ki} = \sum E_{Kf}$ $\sum E_{Ki} = (0.5)(0.20)(3.0^2)+0 = 0.90\text{ J}$ $\sum E_{Kf} = (0.5)\times(0.25)\times(1.8)^2+(0.5)\times(0.20)\times(0.75)^2 = 0.46\text{ J}$ Since kinetic energy is not conserved, the collision is inelastic.	1 1 1 1
24.	To calculate the satellite speed in orbit; $v = \frac{2\pi r}{T}$ $= \frac{2\times\pi\times 1.4\times 10^7}{4.6\times 3600}$ $= 5312\text{ ms}^{-1}$ $= 5.3\times 10^3\text{ms}^{-1}$	2
25.	The change in gravitational potential energy is equal to the work done on the satellite to alter its orbit. Determine the area under the graph between the altitude limits. Area $\cong (2\times 0.40\times 10^7)+(0.5)(2\times 0.40\times 10^7)$ $\cong 1.2\times 10^7\text{ Nmkg}^{-1}$ The mass of the satellite is 300kg, so: Total work done = $300\times 1.2\times 10^7$ J $\cong 3.6\times 10^9$ J The correct answer is 3.6×10^9 J Accept answers in the range: $(3.6\pm 0.6)\times 10^9$ J decrease. Decreasing altitude decreases gravitational potential energy.	1 1 1
26.	$v = \frac{2\pi r}{T}$ $= \frac{2\times\pi\times 7.7\times 10^9}{3.09\times 24\times 3600}$ $= 1.81\times 10^5\text{ ms}^{-1}$ $= 1.8\times 10^5\text{ms}^{-1}$	1 1

27.	Since; $\frac{M_1 v_2}{r} = G\frac{M_1 M_2}{r^2}$ *Then*, $M_2 = \frac{v^2 r}{G}$ $= \frac{(1.81\times10^5)^2 \times 7.7\times10^9}{6.67\times10^{-11}}$ $M_2 = 3.78\times10^{30}$ kg $M_2 = 3.8\times10^{30}$ kg	1 1
28.	Use; $F = \frac{GM_1 M_2}{r^2}$ $= \frac{(6.67\times10^{-11})(3.78\times10^{30})(1.60\times10^{26})}{(7.7\times10^9)^2}$ $= 6.8\times10^{26}$ N	1 1
29.	The planet in question is much closer to its parent star than Earth is to the Sun and the surface temperature on the planet would be very high... much higher than that of Earth.	1

Question	Area of Study 2 - Electronics and Photonics	Mark Allocation
1.	The lamps are identical and in parallel. Each lamp has the same current. The current maximum is 10A. Use; $P = VI$ $I = \frac{21}{12} A = 1.75$ A through each lamp. $n = \frac{10}{1.75} = 5.7$ Answer: The maximum number of lamps that could be used is 5.	1 1
2.	$P = \frac{V^2}{R}$ $21 = \frac{144}{R}$ $R = 6.9\ \Omega$	1 1
3.	Resistance of parallel resistors, Rp. $\text{Rp} = 2.5\ \text{k}\Omega$ $\text{Total resistance} = 5.0 + 5.0 + 2.5\ \text{k}\Omega$ $= 12.5\ \text{k}\Omega$ $\Delta\text{V} = \frac{2.5\text{k}}{12.5\text{k}} \times 20$ $= 4.0\ \text{V}$	1 1 1
4.	When the light intensity is 100 lux, the LDR resistance is 100 Ω. The LDR and variable resistor are in series. The total resistance = 500 Ω $V_{OUT} = \frac{R_2}{R_1 + R_2} \times V_{IN}$ $= \frac{100}{500} \times 12$ $= 2.4$ V	1 1 1
5.	When the light intensity is 1.0 lux, the resistance read from the graph is 1000 Ω. $V_{OUT} = \frac{R_2}{R_1 + R_2} \times V_{IN}$ $5.0 = \frac{1000}{R_1 + 1000} \times 12$ $R_1 = 1400\ \Omega$ $= 1.4\ \text{k}\Omega$	1 1 1

6.	At a temperature of 20^0C, the thermistor has a resistance of 500 Ω (from the graph). The potential difference across resistor R and the LED is mutually 2.2 V (in parallel). So, the potential difference across the thermistor is 9.0 - 2.2 = 6.8 V. To calculate the current in the thermistor; $I = \frac{6.8}{500}$ $=0.0136$ A As there is a current of 10 mA in the LED, there must be a current of 3.6 mA flowing through resistor R. To calculate the resistance, use: $R = \frac{V}{I}$ $= \frac{2.2}{0.0036}$ $=610\ \Omega$	1 1 1 1
7.	To calculate the current in the resistor; $I = \frac{V}{R}$ $= \frac{2.0}{610}$ $=3.3\times10^{-3}$ A $=3.3$ mA Since the current in the LED is 3.7 mA, the total current is: 3.3 + 3.7 = 7.0 mA To calculate the resistance of the thermistor: $R = \frac{V}{I}$ $= \frac{9.0-2.0}{7.0\times10^{-3}}$ $=1000\ \Omega$ From the graph, when the resistance is 1.0 kΩ, the temperature is 10^0C.	 1 1 1
8.	To find I through the 65 Ω resistor. $I = \frac{V}{R}$ $= \frac{12-4.5}{65}$ $= 0.12$ A	 1 1

9.	$\text{Vout} = \frac{R_2}{R_1 + R_2} \times V_{IN}$ $= \frac{350 \times 12}{(350 + 65)}$ $= 10.1$ $= 10\text{ V}$	1 1
10.	Use; $P = \frac{V^2}{R}$ $= \frac{(12 - 10.1)^2}{65}$ $= 0.056\text{ W}$ $= 56\text{ mW}$	 1 1
11.	At a temperature of 25°, the thermistor resistance is 350 Ω. Use; $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ $= \frac{1}{350} + \frac{1}{570}$ So $R_T = 217\ \Omega$ now, add $65\,\Omega$ as it is in series with the parallel resistors $= 217 + 65$ $= 282\,\Omega$ the total current is now $I = \frac{V}{R}$ $= \frac{12}{282}$ $= 0.043\text{ A}$ $= 43\text{ mA}$	 1 1 1

<table>
<tr><td>12.</td><td>Choose from this list (not exhaustive).<table><tr><td>LED properties (advantages):</td><td>Filament light globes compared:</td></tr><tr><td>Durable, can withstand vibration</td><td>Filament will break</td></tr><tr><td>Operate on small voltages</td><td>Usually larger voltages needed</td></tr><tr><td>Longer operation life</td><td>Much shorter life span</td></tr><tr><td>Consume less power</td><td>Usually more power consumed</td></tr><tr><td>Fast response time when turned on</td><td>Slower response time</td></tr></table></td><td>3</td></tr>
<tr><td>13.</td><td>The current through the resistor is 60 mA.
Use;
$V = IR$
$= \frac{60}{1000} \times 250$
$= 15$ V</td><td>1
1</td></tr>
<tr><td>14.</td><td>The supply emf = 15 + 1.8 = 16.8 V
=17 V</td><td>2</td></tr>
<tr><td>15.</td><td>Apart from a very small leakage current, the current in the circuit is essentially zero when the LED is in reverse bias.</td><td>2</td></tr>
<tr><td>16.</td><td>The voltage drop across the LED is 1.8 V.
Since the 500 Ω resistor is in parallel with the LED, the voltage drop across it is also 1.8 V.
Use;
$I = \frac{V}{R}$
$= \frac{1.8}{500}$
$= 3.6$ mA</td><td>1
1</td></tr>
<tr><td>17.</td><td>Gain = Δv out/Δv in
= 10/0.40
= 25</td><td>1
1</td></tr>
<tr><td>18.</td><td>From graph inverting</td><td>2</td></tr>
<tr><td>19.</td><td>$R_{total}=V^2/P$
$R_t= 240^2/480$
$R_t=120\Omega$
Each element 40 Ω</td><td>1
1</td></tr>
<tr><td>20.</td><td>$1/R_{total} = 1/R_1 + 1/R_2 + 1/R_3 = 1/40 + 1/40 + 1/40$
Rt = 13 Ω</td><td>1
1</td></tr>
</table>

21.	An ohmic device obeys Ohm's law: $V = IR$. An ohmic device has a constant resistance, regardless of the applied voltage. A non-ohmic device does not have a constant resistance, since the value of its resistance varies with the value of the applied voltage. Or linear V-I graph originating from the origin for ohmic.	1 1
22.	The best alternative is graph B.	2
23.	Photodiodes and phototransistors are most commonly used as detectors. The detector produces an electric current that has a magnitude directly proportional to the detected light intensity exiting the cable. Thus, electrical signals identical to that which modulated the carrier wave are produced.	1 1 1

SECTION B – Detailed Study

Question	Detailed Study 3.3 – Materials and their use in Structures	
1.	B	Answer **B** The type of stress shown in order from 1 – 3 is compression; tension; shear
2.	C	The torque is at first increasing, then decreasing. Answer **C**
3.	D	Tensile strength is the stress at breaking point under tension so correct answer is D. A is not correct because it will break rather than probably break under this level of tension.
4.	C	Answer **C** Take torques about point A. $\Sigma\tau_{CW} + \Sigma\tau_{ACW} = 0$ $(T\sin 60^0 \times 6) - (800 \times \cos 30^0 \times 18) = 0$ $5.196T - 12470 = 0$ $T = 2400$ N $= 2.4 \times 10^3$ N
5.	C	$x = 40$ cm and at 60 MPa of stress applied the % strain is 0.25% So 0.25% = $\dfrac{\Delta x}{40}$ so $\Delta x = 0.1$ cm, therefore, as the bone will be under compression the length will be 40.0 - 0.1 = 39.9 cm
6.	D	Young's Modulus is given by the gradient of a stress- strain graph. Choose any convenient pair of values within the elastic region. E = $\dfrac{\text{stress}}{\text{strain}}$ $= \dfrac{100 \text{ x } 10^6}{0.40 \times 10^{-2}}$ $= 2.5 \times 10^{10}$ Nm^{-2}
7.	A	Use the graph: Stored energy is numerically equal to the area under the graph between the given parameters. When stress = 100 MPa; strain = 0.40 % change in length. area = $\dfrac{1}{2}(100 \times 10^6)(0.40 \times 10^{-2})$ $= 2.0 \times 10^5$ J
8.	B	The best estimate for the elastic limit of the bone is 100 MPa.
9.	A	The most brittle material is A (no plastic region).
10.	C	The toughest material is C (largest area under the characteristic).
11.	B	Take torques about point A; $\Sigma\tau_{CW} = \Sigma\tau_{ACW}$ $(4500 \times 10 \times 3.0) + (1800 \times 10 \times 6.0) = R_B \times 12$ $R_B = 2.03 \times 10^4$ N $R_B = 2.0 \times 10^4$ N

12.	A	$\Sigma F_{UP} = \Sigma F_{DOWN}$ $R_A + R_B = (4500 \times 10) + (1800 \times 10)$ $R_A = 63000 - 2.04 \times 10^4$ $= 4.3 \times 10^4$ N
13.	B	The beam is balanced in the horizontal position. Take torques about the pivot. $\Sigma \tau_{CW} = 500 \times 0.60$ $= 300$ The weight of the beam acts at the centre of the beam and is 2.0 m from the end. The weight force is acting at a distance of (2.0 - 0.60) m from the pivot. $\Sigma \tau_{ACW} = W \times 1.4$ $\Sigma \tau_{CW} = \Sigma \tau_{ACW}$ $300 = W \times 1.4$ $W = 214$ N so, the mass is $\frac{214}{10} = 21.4$ = 21 kg
14.	A	Take torques about the edge of the tin at the pivot point. Let *F* be the required force. $\Sigma \tau_{CW} = 0.20 \times F$ $\Sigma \tau_{ACW} = 400 \times 0.0080$ $\Sigma \tau_{CW} = \Sigma \tau_{ACW}$ $F = \frac{400 \times 0.0080}{0.20}$ $= 16$ N
15.	C	Concrete has a low tensile strength and the steel is needed where the beam will be under tension which will be close to the upper surface.

End of Suggested Answers