2017 VCE Physics (NHT) examination report

Specific information

This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

Section A – Core studies

Area of study – Motion in one and two dimensions

Question 1a.

This was a kinematics problem.

$u = 0$, $a = 0.5$, $t = 10.0$, $x = ?$

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

$$x = 0.5 \times 0.5 \times 10^2$$

$$x = 25 \text{ m}$$

Question 1b.

Apply Newton's second law to the whole mass.

$$F = ma$$
$$F = (100 \times 10^3 + 200 \times 10^3 + 200 \times 10^3) \times 0.5$$
$$F = 2.5 \times 10^5 \text{ N}$$

Question 1c.

Apply Newton's second law to the barges alone.

$$T = ma$$
$$T = (200 \times 10^3 + 200 \times 10^3) \times 0.5$$
$$F = 2.0 \times 10^5 \text{ N}$$

Question 1d.

There were two ways to solve this question. The solution with the fewest steps was:

$$I = Ft$$
$$I = (200 \times 10^3 \times 0.5) \times 10.0$$
$I = 1.0 \times 10^6$ N s or kg m s^{-1}

The slightly longer solution required solving for final velocity:

$u = 0$, $a = 0.5$, $t = 10.0$, $v = ?$

$v = u + at$

$v = 0 + 0.5 \times 10.0$

$v = 5 \text{ m s}^{-1}$

This value is then used to calculate I:

$I = mv$

$I = 200 \times 10^3 \times 5$

$I = 1.0 \times 10^6$ N s or kg m s^{-1}

Question 2a.

Apply conservation of momentum.

$$(2.0 \times 3.0) + (1.0 \times 1.0) = (2.0 \times 2.0) + (1.0 \times v)$$

$$7 = 4 + v$$

$$v = 3 \text{ m s}^{-1}$$

Question 2bi.

Students were required to identify that **kinetic** energy is conserved in elastic collisions, and that in inelastic collisions kinetic energy is lost during the collision.

Question 2bii.

To determine whether the collision is elastic or inelastic, the kinetic energies are calculated before and after the collision.

Before:

$$E = \frac{1}{2}mv^2$$

$$E = 0.5 \times 2.0 \times 4.0^2$$

$$E = 16 \text{ J}$$

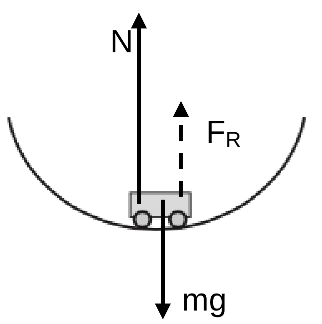
After:

$$E = (0.5 \times 2.0 \times 2.0^2) + (0.5 \times 1.0 \times 4.0^2)$$

$$E = 12 \text{ J}$$

Since the final kinetic energy is less than the initial kinetic energy, the collision is inelastic.

Question 3a.



Question 3b.

Students must ensure that they include the gravitational weight force as well as the centripetal force.

$$F = \frac{mv^2}{r} + mg$$

$$F = \frac{50 \times 24^2}{12} + 50 \times 10$$

$$F = 2900 \text{ N}$$

Question 3c.

Students were required to explicitly state that Emily is correct.

Even though gravity is still present, at the top of the loop if the reaction force (N) equals zero then a person would feel weightless.

Question 4a.

Students should equate mg to kx.

$$mg = kx$$

$$m \times 10 = 20 \times 0.6$$

$$m = 1.2 \text{ kg}$$

Question 4b.

Students were required to find the spring potential energy at both Q and S.

At Q:

$$E_S = \frac{1}{2}kx^2$$

$$E_S = 0.5 \times 20 \times 0.4^2$$

$$E_S = 1.6 \text{ J}$$

At S:

$$E_S = \frac{1}{2}kx^2$$

$$E_S = 0.5 \times 20 \times 0.8^2$$

$$E_S = 6.4 \text{ J}$$

Energy difference:

$$6.4 - 1.6 = 4.8 \text{ J}$$

Question 4c.

- Total energy: **Graph C**. The system is a closed system and total energy is conserved.
- Gravitational potential energy: **Graph B**. The gravitational potential energy is zero at the bottom of the oscillation as stated in the question stem.
- Kinetic energy: **Graph D**. The mass moves fastest in the middle of the oscillation, and is momentarily stationary at the top and bottom.
- Spring potential energy: **Graph E**. The spring potential energy is greater than zero at the top of the oscillation and increases proportionally with x^2 as the mass descends.

Question 5a.

This question required students to find the time of flight for the arrow then use that to find the horizontal range.

u = 0, a = –10, x = –1.0, t = ?

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

$$-1 = 0.5 \times -10 \times t^2$$

$$t = 0.45 \text{ sec}$$

$$x = vt$$
$$x = 12 \times 0.45$$
$$x = 5.4 \text{ m}$$

Question 5b.

There were two approaches that could be used here. The first was a basic kinematics approach:

$u_{vert} = 12\text{sin}30 = 6.0 \text{ m s}^{-1}$ $v_{horiz} = 12\text{cos}30 = 10.4 \text{ m s}^{-1}$

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

$$0 = 6t - 5t^t$$

$$5t^2 - 6t = 0$$

$$\Rightarrow t = 1.2 \text{ sec}$$

$$R = vt$$

$$R = 10.4 \times 1.2$$

$$R = 12.5 \text{ m}$$

An alternative approach was to use the range equation:

$$R = \frac{v^2 sin2\theta}{a}$$

$$R = \frac{12^2 \times sin(2 \times 30)}{10}$$

$$R = 12.5 \text{ m}$$

Students are reminded to use caution with derived formulas as no marks are awarded for substitution into an incorrect formula.

Question 5c.

The correct approach was to equate spring potential energy to kinetic energy, where the spring potential energy is found from the area under the graph.

$$\frac{1}{2}bh = \frac{1}{2}mv^2$$

$$0.5 \times 0.2 \times 120 = 0.5 \times 0.03 \times v^2$$

$$12 = 0.015 \times v^2$$

$$v = 28.3 \text{ m s}^{-1}$$

Question 6a.

248 years = 7.8×10^9 s

Question 6b.

The correct approach was to equate Newton's law of gravitation to one of the circular motion formulas.

$$\frac{GMm}{r^2} = \frac{4\pi^2 rm}{T^2}$$

$$r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$$

$$r = \sqrt[3]{\frac{(6.67 \times 10^{-11}) \times (2.0 \times 10^{30}) \times (7.8 \times 10^9)^2}{4\pi^2}}$$

$$r = 5.9 \times 10^{12} \text{ m}$$

Question 6c.

The correct approach was to firstly recognise that *v* will be zero at the top of flight in both cases. Therefore:

$$u_{earth}^2 + 2a_{earth}x = u_{pluto}^2 + 2a_{pluto}x$$

Since *u* is the same in both cases, it can be cancelled from both sides of the equation.

$$2 \times 10 \times 5.0 = 2 \times 0.62 \times x$$

$$x = \frac{100}{1.24}$$

$$x = 80.6 \text{ m}$$

Area of study – Electronics and photonics

Question 7a.

There were a number of approaches that could have been used here. The most straightforward was to find the equivalent resistance of the parallel network:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{60} + \frac{1}{30}$$

$$R_{eq} = 20\ \Omega$$

Since the other two fixed resistors are also 20 Ω, each will drop one third of the voltage.

$$\frac{1}{3} \times 18 = 6\ \text{V}$$

Other approaches involved finding the total resistance of the circuit (60 Ω) and using this to find the supply current (0.3 A). Two-thirds of the current will flow through the 30 Ω resistor (0.2 A), so the voltage drop can be calculated using Ohm's law.

$$V = RI$$
$$V = 30 \times 0.2$$
$$V = 6\ \text{V}$$

Question 7b.

A number of alternative approaches could have been used here. The first was to find the supply current if it was not found in Question 7a.

$$I = \frac{V_{supply}}{R_{total}}$$

$$I = \frac{18}{60} = 0.3\ \text{A}$$

Because the resistor ratio is 2:1, the current ratio will be 2:1 and thus 0.1A will flow through the 60 Ω resistor.

Alternatively, use the 6 V calculated in Question 7a. and Ohm's law to solve for *I*:

$$I = \frac{V}{R}$$

$$I = \frac{6}{60} = 0.1\ \text{A}$$

Question 7c.

Since the equivalent resistance of two identical resistors in parallel is half the resistor value, the two 80 Ω resistors have an equivalent resistance of 40 Ω.

Students were then expected to identify that after dropping 1.0 V across the diode, the remaining 16 V would be dropped equally across the parallel component and the single 40 Ω resistor. This gives **8.0 V** across either of the 80 Ω resistors.

Question 7d.

Using the 8.0 V calculated in Question 7c., the current through either of the 80 Ω resistors can be found using Ohm's law.

$$I = \frac{V}{R}$$

$$I = \frac{8}{80} = 0.1 \text{ A}$$

Question 8a.

This problem required a couple of steps. The first was to find the voltage across the resistor.

$$P = \frac{V^2}{R}$$

$$\therefore V = \sqrt{P \times R}$$

$$V = \sqrt{0.05 \times 500} = 5.0 \text{ V}$$

To find the voltage across the diode required finding the current through the resistor.

$$P = I^2 R$$

$$\therefore I = \sqrt{\frac{P}{R}}$$

$$I = \sqrt{\frac{0.05}{500}} = 0.01\, A \text{ (10 mA)}$$

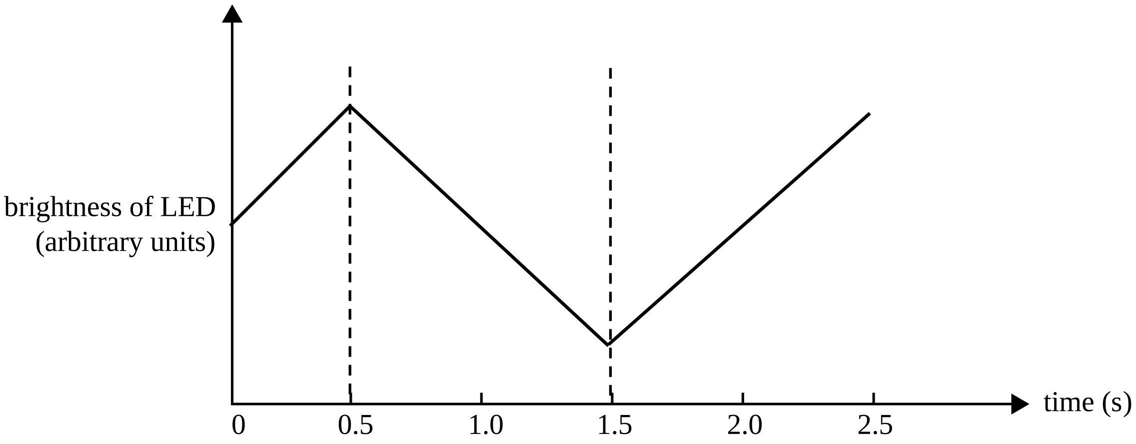
From the graph, when a current of 10 mA passes through the diode it drops ~0.9 V. It was incorrect to assume that the diode would be dropping 1.0 V since the graph shows that the diode does not drop 1.0 V until the forward current is approximately 15 mA.

Once the diode forward voltage (0.9V) and the resistor voltage (5.0 V) have been found they should be summed to find the final supply voltage of **5.9 V**.

Question 8b.

If the battery is reversed the diode will be reverse biased. In this case no current will flow and the voltage across it will be the voltage found in Question 8a., **5.9V**.

Question 9



The important features that students were required to show were that the graph is inverted. That is, that increases in the resistance result in decreases in the brightness of the LED and since the stem stated that the diode is 'always conducting', the brightness should not go to zero at any point.

Question 10a.

From the graph the LDR has a resistance of 2 kΩ.

Since the ratio of the voltages R:LDR is 6:4, the resistances must have the same ratio.

$\frac{6 \times 2000}{4} = 3000\Omega$

The answer needed to be in kΩ, so the correct response was **3 kΩ**.

Question 10b.

Since the ratio of the voltages R:LDR is 7.5:2.5, the resistance must also be in a 3:1 ratio.

From Question 10a. the fixed resistor, R, is 3000 Ω, so the LDR must be 1000 Ω.

From the graph the LDR has a resistance of 1000 Ω at **10 lux**.

Question 11a.

The gain is defined as the output voltage divided by the input voltage.

$$A = \frac{V_{out}}{V_{in}}$$

$$A = \frac{4}{10 \times 10^{-3}} = 400$$

Question 11b.

Clipping occurs when the input voltage exceeds the linear region. This occurs at 10 mV peak.

$$V_{RMS} = \frac{V_{peak}}{\sqrt{2}} = 7.1 \text{ mV}$$

Area of study – Electric power

Question 12a.

The correct response was **B**.

The reason is that both the inner ends of the solenoids are north magnets. Therefore, the field at X is downwards. The magnetic compass will align itself with this field.

Question 12b.

The correct response was **G**.

The reason is that the net field along the line that the wire occupies is vertical. The current is, therefore, running parallel to the field lines. In this case the force will be zero.

Question 13a.

The force on the wire can be calculated thus:

$F = BIl$
$F = 0.02 \times 0.5 \times 0.05$
$F = 5 \times 10^{-4}$ N

Question 13b.

Students were required to identify that the loop would rotate anticlockwise.

The reason is that the current flows from W to X and from Y to Z. Using a rule such as the right-hand slap rule shows that the side WX will be forced down while the side YZ will be forced upwards resulting in anticlockwise rotation.

Question 13c.

Students were required to identify that the role of the commutator is to reverse the direction of the current every half turn to keep the motor rotating in the same direction.

Questions 14a. and 14b.

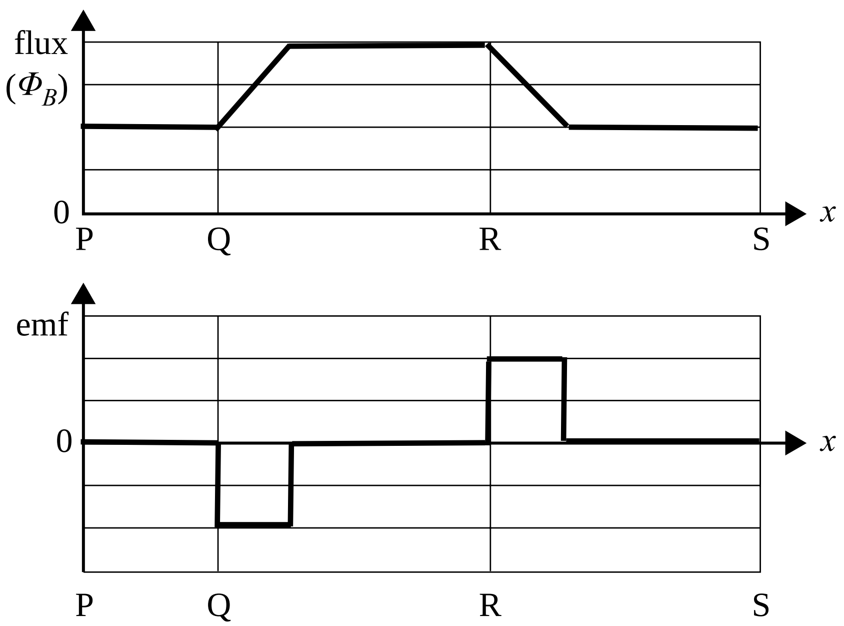


Figure 23b

Figure 23c

Question 14c.

The current will flow from **X to Y**.

The loop experiences an increasing, downwards flux.

According to Lenz's law the induced current will produce an increasing, upwards flux to oppose the initial change in flux.

By applying one of the right-hand rules the current can be found to flow from X to Y.

Question 14d.

To solve this problem the induced emf needed to be found.

$$\xi = -\frac{\Delta\phi}{\Delta t} = -B\frac{\Delta A}{\Delta t}$$

$$\xi = 2.0 \times 10^{-3} \times \frac{(10 \times 10^{-2})^2}{0.50}$$

$$\xi = 4.0 \times 10^{-5} \text{ V}$$

The minus sign has been dropped since only the magnitude is required.

Now Ohm's law is applied to find the current.

$$I = \frac{V}{R}$$

$$I = \frac{4.0 \times 10^{-5}}{2.0}$$

$$I = 2.0 \times 10^{-5} \text{ A}$$

Question 15a.

This was a power calculation.

$$P = \frac{V^2}{R}$$

$$P = \frac{240^2}{10}$$

$$P = 5760 \text{ W}$$

Question 15b.

There were a few ways to solve this problem.

One way was to find the transmission current:

$$I = \frac{V}{R} = \frac{240}{16}$$

$$I = 15 \text{ A}$$

This current is then used to calculate the power used by the coolroom equipment:

$P = I^2R = 15^2 \times 10$
$P = 2.25 \times 10^3$ W

An alternative is to use the resistance ratio of $\frac{10}{16}$ to find the voltage across the coolroom equipment.

$$\frac{V}{240} = \frac{10}{16}$$

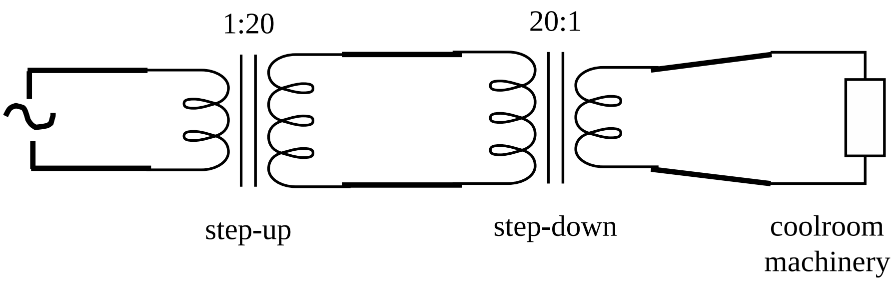
$V = 150$ V

This is then used to calculate power:

$$P = \frac{V^2}{R} = \frac{150^2}{10}$$

$P = 2.25 \times 10^3$ W

Question 15c.



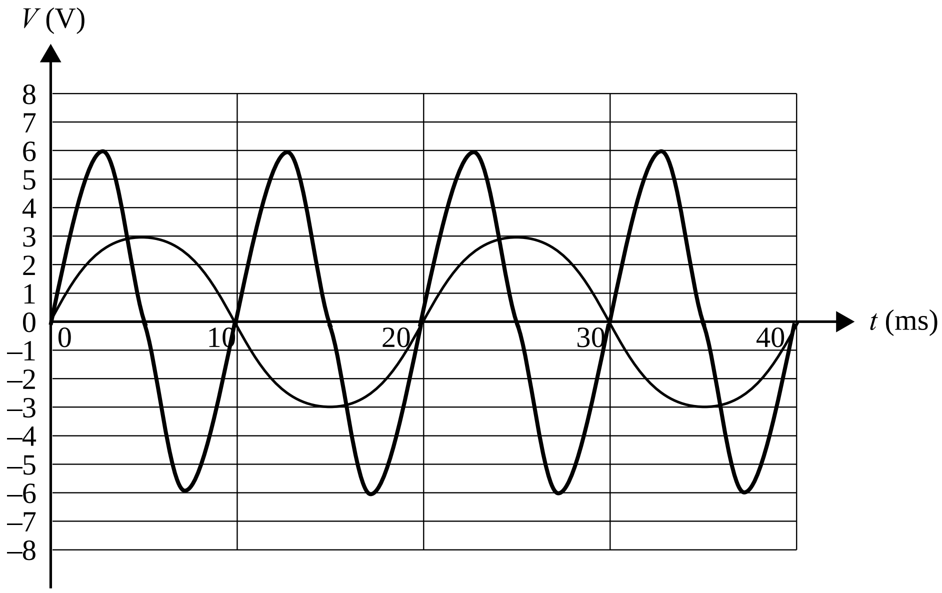
Question 16a.

Frequency is the reciprocal of period.

$$f = \frac{1}{T} = \frac{1}{20 \times 10^{-3}}$$

$f = 50$ Hz

Question 16b.



Note, double the amplitude and double the frequency.

Question 17a.

The second dark region is due to a 1.5 wavelength difference.

$PD = 1.5\lambda = 1.5 \times 3.0$
$PD = 4.5 \text{ cm}$

Question 17b.

Students were required to identify that Young's experiment demonstrated interference and that interference is a property of waves.

Therefore, Young's experiment supports the wave model of light.

Question 17c.

$$y \propto \frac{\lambda}{w}$$

Therefore, if the wavelength (λ) increases, the width of the pattern (y) will also increase.

Question 18a.

$$E = \frac{hc}{\lambda}$$

$$E = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{500 \times 10^{-9}}$$

$$E = 2.5 \text{ eV}$$

Students are reminded to check which Planck's constant they are using.

Question 18b.

From the graph, **1.5 eV**.

Question 18c.

The work function is defined as the difference between the energy of the incident photon and the kinetic energy of the photoelectron.

$$W = E_{photon} - KE_{photoelectron}$$

$$W = 2.5 - 1.5 = 1.0 \text{ eV}$$

Question 18d.

At V = +1.0 V all of the available photoelectrons are being collected. Since there are no more photoelectrons to be collected, increasing the voltage will not result in an increase in photocurrent.

Question 18e.

The correct response was **D**.

Question 18f.

Students were required to identify that the increase in photocurrent without increasing the stopping voltage supports the particle model of light rather than the wave model. The particle model predicts that increasing the intensity will increase the number of photons released but not the energy of the photons. Therefore the photocurrent will increase but the stopping voltage will not.

The wave model predicts that increasing the intensity will increase the kinetic energy of the photoelectrons, which would increase the stopping voltage. This is not what is observed.

Question 19a.

$$\lambda_d = \frac{h}{mv}$$

$$\lambda_d = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2 \times 10^{7}}$$

$$\lambda_d = 0.036 \text{ nm}$$

Students are reminded to check which version of Planck’s constant they are using.

Question 19b.

$$E = \frac{hc}{\lambda}$$

$$E = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{0.1 \times 10^{-9}}$$

$$E = 1.242 \times 10^{4} \text{ eV}$$

Students are reminded to check which version of Planck’s constant they are using.

Question 20

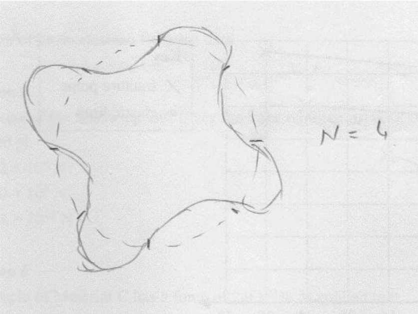
The three possible photon energies were: 3.19 eV, 2.11 eV, 1.08 eV.

Question 21

Electrons exhibit a wave behaviour.

Electrons form standing waves in orbits where the circumference is a whole multiple of the electron wavelength.

This means that only certain discrete energy states can exist.



Section B

Detailed Study – Materials and their use in structures

Question	Answer	Comments
1	C	Material **C** shows elastic behaviour over the widest range of strain values.
2	A	Material **A** shows the greatest strain prior to fracture.
3	D	$E = \frac{\sigma}{\varepsilon}$ $E = \frac{200 \times 10^6}{12 \times 10^{-3}}$ $E = 1.7 \times 10^{10}\ \text{Pa}$
4	A	Material **A** has the largest area under the graph.
5	B	$\sigma = \frac{F}{A}$ $F = 300 \times 10^6 \times 4 \times 10^{-3}$ $F = 1.2 \times 10^6\ \text{N}$
6	B	$\sigma = \frac{F}{A} = \frac{2 \times 10^5}{4 \times 10^{-3}}$ $\sigma = 5 \times 10^7\ \text{MPa}$ Now: $E = \frac{\sigma}{\varepsilon}$ where E = 1.67 × 10^{10} MPa So: $\varepsilon = \frac{5 \times 10^7}{1.67 \times 10^{10}}$ $\varepsilon = 3 \times 10^{-3}$ Finally: $\varepsilon = \frac{\Delta L}{L}$ $\Delta L = 3 \times 10^{-3} \times 0.5$ $\Delta L = 1.5 \times 10^{-3}\ \text{m}$
7	A	The rotational force produced by fixing the drum at one end and hanging the mass at the other produces a shear stress in the drum.

8	C	$\tau = Fd$ $\tau = 50000 \times 5$ $\tau = 2.5 \times 10^5$ N m
9	D	$\Sigma\tau = 0$ $(50000 \times 5) + (5000 \times 10) = F_{up} \times 8$ $F_{up} = 3.75 \times 10^4$ N Note, this is not the tension in the cable. It is the vertical component of the tension. $T = \frac{3.75 \times 10^4}{\sin 30}$ $T = 7.5 \times 10^4$ N
10	D	Low down between O and P and high up beyond P
11	A	PQ, QS, and ST are all in compression. QR and RS are in tension.