Diploma Programme
Programme du diplôme
Programa del Diploma

# Physics
# Standard level
# Paper 2

Monday 15 May 2017 (afternoon)

1 hour 15 minutes

Candidate session number

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 17 | M | TZ | 1 | P | 2 | A | M | S | L |

**Instructions to candidates**

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

$\frac{37}{50} = 74\%$



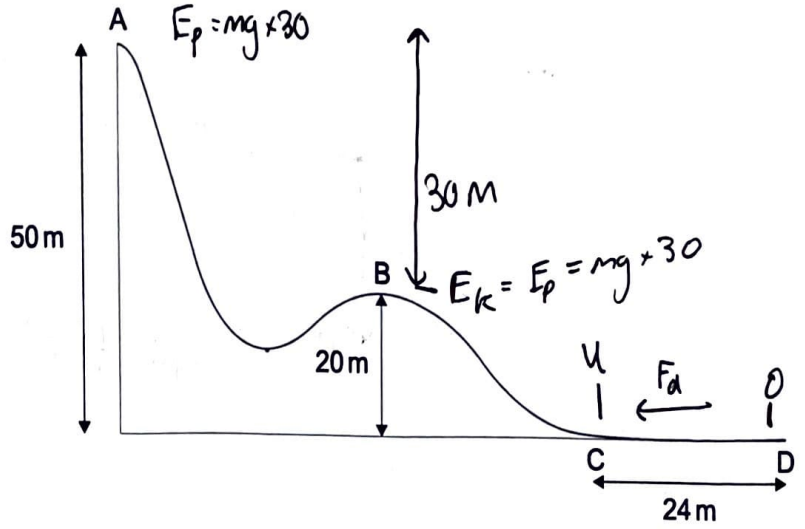
2217–6511

Please **do not** write on this page.

Answers written on this page
will not be marked.

Answer **all** questions. Answers must be written within the answer boxes provided.

**1.** The diagram below shows part of a downhill ski course which starts at point A, 50 m above level ground. Point B is 20 m above level ground.




(a) A skier of mass 65 kg starts from rest at point A and during the ski course some of the gravitational potential energy transferred to kinetic energy.

(i) From A to B, 24 % of the gravitational potential energy transferred to kinetic energy. Show that the velocity at B is 12 $m s^{-1}$. [2]

$E_P = mgoh = 65 \times 9.81 \times 30$
$= 19129.5\ J$
$E_k = 0.24 \times 19129.5 = \frac{1}{2} mv^2$ ✓
$\therefore v = \sqrt{\frac{2 \times 0.24 \times 19129.5}{65}} \approx 12\ ms^{-1}$ ✗
must be 11.9

DATA
$m = 65kg$
$u = 0\ ms^{-1}$
$v = 12\ ms^{-1}$

(ii) Some of the gravitational potential energy transferred into internal energy of the skis, slightly increasing their temperature. Distinguish between internal energy and temperature. [2]

Internal energy refers to the kinetic and potential energy of molecules within the material ✓ while temperature refers to the heat that is transferred when two objects are not in equilibrium. ✗ T measure of average KE of particles

**(This question continues on the following page)**

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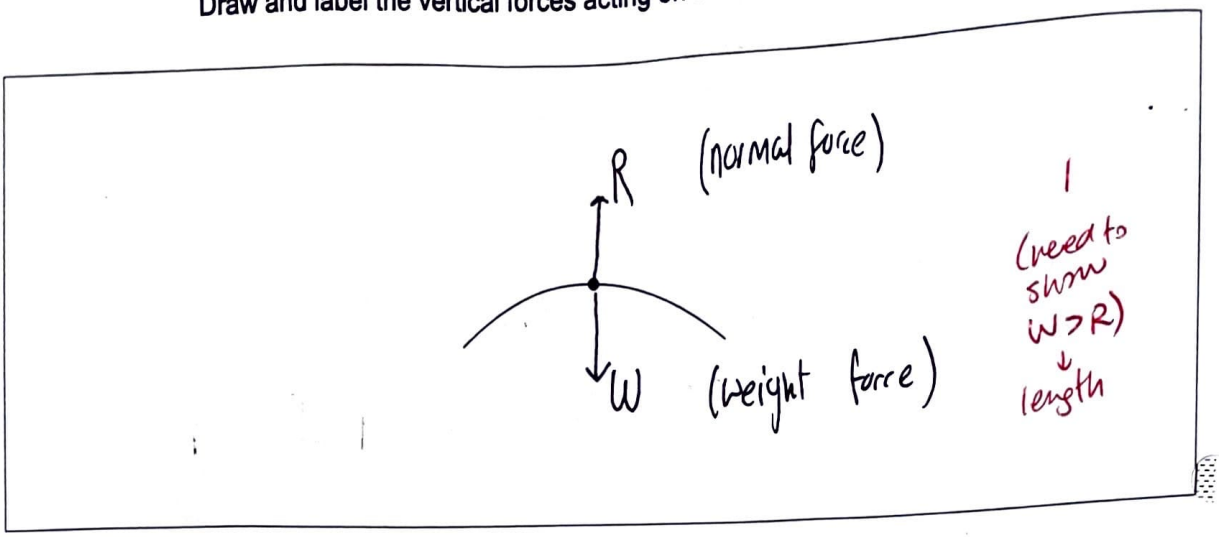
**(Question 1 continued)**

(b) (i) The dot on the following diagram represents the skier as she passes point B. Draw and label the vertical forces acting on the skier. [2]




1
(need to show W > R)
↓
length

(ii) The hill at point B has a circular shape with a radius of 20 m. Determine whether the skier will lose contact with the ground at point B. [3]

$F_c = \frac{mv^2}{r} = \frac{65 \times 12^2}{20} = 325\ N$ (force required) ✓ 468 ×

$W = 65 \times 9.81 = 637\ N$

DATA
$r = 20\ m$
$m = 65\ kg$
$v = 12\ ms^{-1}$

$\Rightarrow W > F_c$ ; the skis will not leave the ground ✓

(c) The skier reaches point C with a speed of $8.2\ ms^{-1}$. She stops after a distance of 24 m at point D.

Determine the coefficient of dynamic friction between the base of the skis and the snow. Assume that the frictional force is constant and that air resistance can be neglected. [3]

$v^2 = u^2 + 2as \rightarrow a = \frac{v^2 - u^2}{2s}$

$\therefore a = 8.2^2/2 \times 24 = 1.40\ ms^{-2}$ ✓

$F = ma \rightarrow F = 65 \times 1.40 = 91\ N = f$ ✓

$\therefore F = \mu_d R \rightarrow \mu_d = \frac{F}{65 \times 9.81} = \frac{91}{65 \times 9.81} = 0.143$ ✓

0.14

$u = 8.2\ ms^{-1}$
$v = 0\ ms^{-1}$
$s = 24\ m$
$a = ?$

**(This question continues on the following page)**

**(Question 1 continued)**

(d) At the side of the course flexible safety nets are used. Another skier of mass 76 kg falls normally into the safety net with speed 9.6 $m s^{-1}$.

(i) Calculate the impulse required from the net to stop the skier and state an appropriate unit for your answer. [2]

impulse = $\Delta p$ = $(mv)_i - (mv)_f$
= $76 \times 9.6$ ✓
= 729.6 N s
= 730 N s ✓

DATA
$m = 76$ kg
$u = 9.6\ ms^{-1}$ ✓
$v = 0\ ms^{-1}$ ✓

(ii) Explain, with reference to change in momentum, why a flexible safety net is less likely to harm the skier than a rigid barrier. [2]

Flexible safety nets will extend the time over which the change in momentum occurs. ✓
Therefore, the ~~force~~ exerted on the skiier will be smaller impulse ✓

borderline. Need $\frac{\Delta p}{\Delta t}$
$F =$

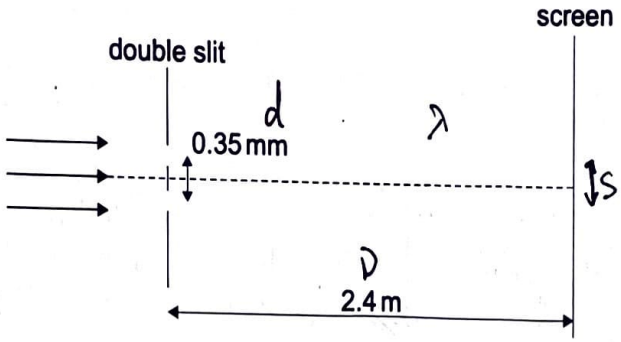
4/4

**2.** (a) Outline what is meant by the principle of superposition of waves. [2]

Superposition of waves refers to what happens when waves overlap each other. During superposition, the resulting wave at each point will equal the sum of the heights of both waves. ✓ overlapping

vector ✗

(b) Red laser light is incident on a double slit with a slit separation of 0.35 mm. A double-slit interference pattern is observed on a screen 2.4 m from the slits. The distance between successive maxima on the screen is 4.7 mm.




(not to scale)

Calculate the wavelength of the light. Give your answer to an appropriate number of significant figures. [3]

$s = 4.7 \times 10^{-3}$

$\lambda = sd/D$ ← $\{ s = \frac{4.7 \times 10^{-3}}{2} = 2.35 \times 10^{-3} \text{ m} \}$ ✗

$= \frac{2.35 \times 10^{-3} \times 0.35 \times 10^{-3}}{2.4}$

$\simeq 3.4271 \times 10^{-7}$ m ECF

$= 3.4 \times 10^{-7}$ m ✓

$= 340$ nm ✓ 2 sf

DATA
~~$s = 4.7 \times 10^{-3}$ m~~
$D = 2.4$ m
$d = 0.35 \times 10^{-3}$ m
$2s = 4.7 \times 10^{-3}$ m

**(This question continues on the following page)**

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**(Question 2 continued)**

(c) Explain the change to the appearance of the interference pattern when the red-light laser is replaced by one that emits green light. [2]

green light has shorter wavelengths → $s = \frac{\lambda D}{d}$ ✓

Therefore, the distance between maxima and minima on the screen, s, will decrease. ✓

(d) One of the slits is now covered.

Describe the appearance of the pattern on the screen. [2]

The light will diffract as it enters through the single slit. This means that the light on the screen will observe a greater surface area than the slit's opening. No superposition or interference will occur.

with decreasing intensity around the border.

x bright central maximum

x subsidiary maxima on either side

2/4

**3.** Two renewable energy sources are solar and wind.

(a) Describe the difference between photovoltaic cells and solar heating panels. [1]

electrical energy

Photovoltaic cells transfer solar radiation into electricity, while solar heating panels simply absorb energy from the solar radiation to heat up something (e.g. water)

thermal energy

(b) A solar farm is made up of photovoltaic cells of area 25000 $m^2$. The average solar intensity falling on the farm is 240 $W m^{-2}$ and the average power output of the farm is 1.6 MW. Calculate the efficiency of the photovoltaic cells. [2]

Ideal power output = $240 \times 25000 = 6.0 \times 10^6$ W

Actual power output = $1.6 \times 10^6$ W

$e = \frac{1.6 \times 10^6}{6.0 \times 10^6} = 26.7\% = 27\%$

(c) An alternative generation method is the use of wind turbines.

The following data are available:

| | |
|---|---|
| Length of turbine blade | = 17 m |
| Density of air | = 1.3 $kg m^{-3}$ |
| Average wind speed | = 7.5 $m s^{-1}$ |

(i) Determine the minimum number of turbines needed to generate the same power as the solar farm. [3]

$A = \pi r^2 = \pi (17)^2 = 907.92\ m^2$

power $= \frac{1}{2} A \rho v^3$

$= \frac{1}{2} (907.92)(1.3)(7.5^3)$

$= 2.48969 \times 10^5$ W

CONTINUED IN ANSWER BOOKLET

DATA

$r = 17$ m

$\rho = 1.3\ kg\ m^{-3}$

$v = 7.5\ m s^{-1}$

**(This question continues on the following page)**

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**(Question 3 continued)**

(ii) Explain **two** reasons why the number of turbines required is likely to be greater than your answer to (c)(i). [2]

1) Energy will be lost due to ~~eff~~ friction in the turbine mechanism (inefficiencies) ✓2
2) ~~Constant~~ There may be a shortage of wind, meaning the ~~num~~ number of turbines required, ~~num~~ increases. ✗

↳ I want to award this but it's not in the marking criteria/rubric

1/2

**4.** A heater in an electric shower has a power of 8.5 kW when connected to a 240 V electrical supply. It is connected to the electrical supply by a copper cable.

The following data are available:

| | |
|---|---|
| Length of cable | = 10 m |
| Cross-sectional area of cable | = 6.0 mm$^2$ |
| Resistivity of copper | = $1.7 \times 10^{-8}\ \Omega$m |

(a) (i) Calculate the current in the copper cable. [1]

~~$I = P/A = (8.5\times10^3)/240 = 3.5417\times10^{-5}$ A~~

$I = P/V = 8.5\times10^3 / 240 = 35.417\text{ A} = 35\text{ A}$ ✓

DATA
$P = 8.5\times10^3$ W
$V = 240$ V

(ii) Calculate the resistance of the cable. [2]

$R = \frac{\rho L}{A} = \frac{1.7\times10^{-8}\times10}{6.0\times10^{-3}}$ ✓

$= 2.833\times10^{-5}\ \Omega$

$\therefore R \approx 2.8\times10^{-5}\ \Omega$ ×

$0.028\ \Omega = 2.8\times10^{-2}\ \Omega$

DATA
$R = ?$
$\rho = 1.7\times10^{-8}\ \Omega$m
$A = 6.0\times10^{-3}$ m$^2$
$L = 10$ m

(b) Explain, in terms of electrons, what happens to the resistance of the cable as the temperature of the cable increases. [3]

As temperature increases, the average kinetic internal energy of the ~~atoms~~ atoms in the wire will increase, increasing vibration. Speed. This way, the electrons travelling through the medium will experience greater collisions with the atoms, therefore increasing resistance. ✓

drift velocity decreases so I decreases ×

V constant ∴ R increases ×

**(This question continues on the following page)**

The higher the temperature, the more that atoms within the coppe will vibrate. ∴ There will be more collisions, increasing resistance. As ~~$I = nAvq$~~ As $R = \frac{V}{I}$ (resistance increases), and $I = nAvq$, then the drift speed of electrons will decrease. 3/6

**(Question 4 continued)**

(c) The heater changes the temperature of the water by 35 K. The specific heat capacity of water is 4200 $J\,kg^{-1}K^{-1}$.

Determine the rate at which water flows through the shower. State an appropriate unit for your answer. [4]

$\frac{Q}{\Delta t} = \frac{m}{\Delta t} \times c\Delta T$ ✓

$\therefore \frac{m}{\Delta t} = (8.5 \times 10^3\ J) / (4200)(35)$ ✓

$\therefore \frac{m}{\Delta t} = 0.05782\ kg\ s^{-1}$

$\therefore \frac{m}{\Delta t} = 0.058\ kg\ s^{-1}$

$\therefore \frac{m}{\Delta t} = 58\ g\ s^{-1}$ ✓ ✓

DATA

$\Delta T = 35\ K$

$c_w = 4200\ J\,kg^{-1}K^{-1}$

$P = 8.5 \times 10^3\ W$

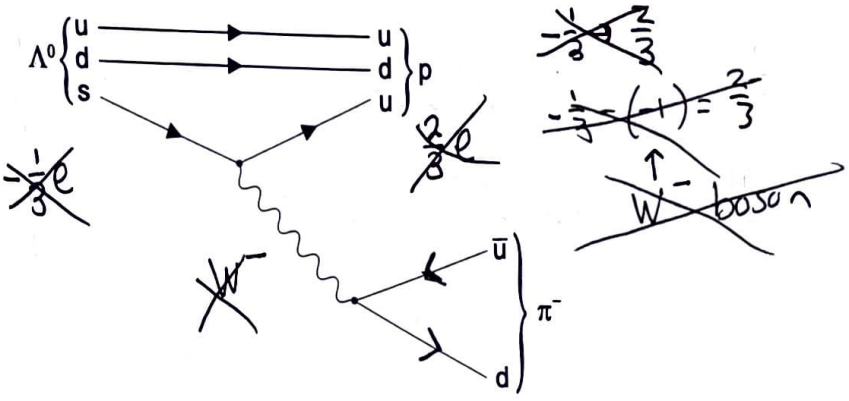
4/4

**5.** (a) State the quark structures of a meson and a baryon. [2]

Meson: ~~Has two quarks~~ Has one quark and ~~one~~ one antiquark ✓ (baryon num = 0)

Baryon: Has three quarks ✓ (baryon num = 1)

(b) A possible decay of a lambda particle ($\Lambda^0$) is shown by the Feynman diagram.




(i) Explain which interaction is responsible for this decay. [2]

Strangeness not conserved

The charge goes from $-\frac{1}{3}e$ to $\frac{2}{3}e$ (taking away a negative charge). Therefore, the $W^-$ boson is responsible for mediating this interaction. For this reason, the weak interaction occurs (formula book)

(ii) Draw arrow heads on the lines representing $\bar{u}$ and d in the $\pi^-$. [1]

**(This question continues on the following page)**

**(Question 5 continued)**

(iii) Identify the exchange particle in this decay. [1]

$-\frac{1}{3}e - (-e) = +\frac{2}{3}e$ $(s \rightarrow u)$

"taking away a negative charge" → $W^-$ boson ✓

(c) Outline **one** benefit of international cooperation in the construction or use of high-energy particle accelerators. [1]

The high cost of high energy particle accelerators can be shared, decreasing investment costs (capital). ✓

2/2