COMMACK HIGH SCHOOL

INTERNATIONAL BACCALAUREATE STANDARD LEVEL PHYSICS

SPRING 2019 SL REVIEW

PART A

May 2017	**Papers 1**	(Dr.S 3/25)
" "	**Papers 2**	(Ms.B 4/30, 5/7)
" "	**Papers 3**	(Ms. B 5/18)
May 2018	**Papers 1**	(Ms. B 5/15)
" "	**Papers 2**	(Dr. G 5/8, 5/16)
" "	**Papers 3**	(Dr.S 4/8 Part A)
More Practice Paper 3 Option B		(Ms.B 5/18)

NAME _____

TEACHER _____

The IB Data Booklet (Reference Tables) can be used on all portions of the exam.

Paper 1: 30 Multiple Choice – 45 minutes
NO CALCULATORS

Paper 2: 1 hour 15 minutes
Complete all parts .

Paper 3: 1 hour
Section A: Answer all questions.
Section B: .(The test booklet includes 4 options.)
Do Option B ONLY! Engineering Physics:
Rigid bodies and Rotational Dynamics
Thermodynamics.

- May 2016, 2017 and 2018 Exams follow the same exam format as the test you will take in May 2019.
- Please also note that the exams prior to 2016:
  - Contain some concepts that will not be on your exam
  - New concepts first tested in 2016 are missing.

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 1

Monday 15 May 2017 (afternoon)

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[30 marks]**.

2217–6510

16 pages

1. What is the unit of electrical energy in fundamental SI units?

A. $kg\,m^2C^{-1}s$

B. $kg\,m\,s^{-2}$

C. $kg\,m^2s^{-2}$

D. $kg\,m^2s^{-1}A$

2. Which of the following is a scalar quantity?

A. Velocity

B. Momentum

C. Kinetic energy

D. Acceleration

3. An object is released from rest in the gravitational field of the Earth. Air resistance is negligible. How far does the object move during the fourth second of its motion?

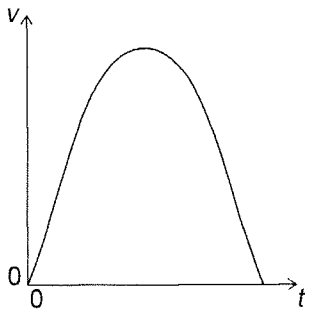
A. 15 m

B. 25 m

C. 35 m

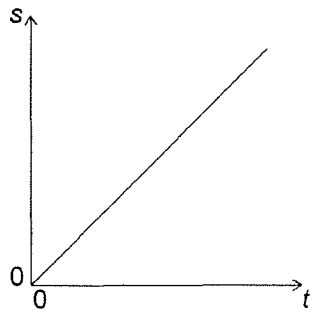
D. 45 m

4. The graph shows the variation of speed v of an object with time t.

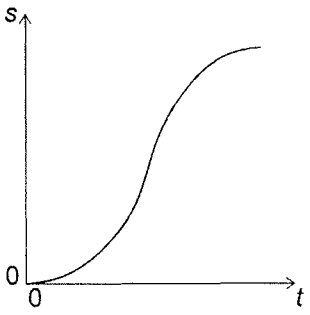


Which graph shows how the distance s travelled by the object varies with t?

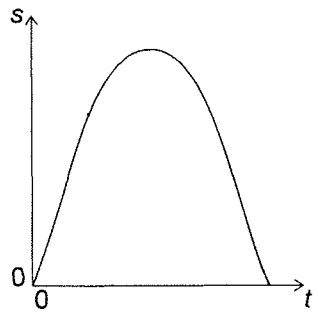
A.



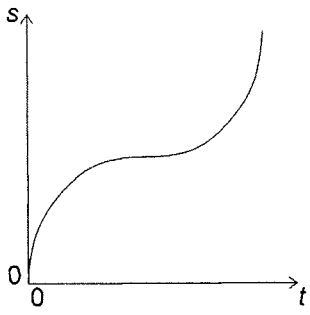
B.



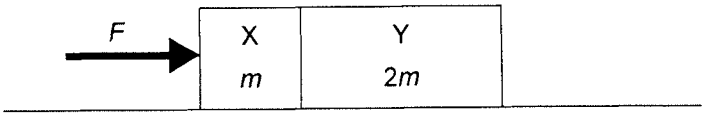
C.



D.



5. Two boxes in contact are pushed along a floor with a force F. The boxes move at a constant speed. Box X has a mass m and box Y has a mass $2m$.



What is the resultant force acting on Y?

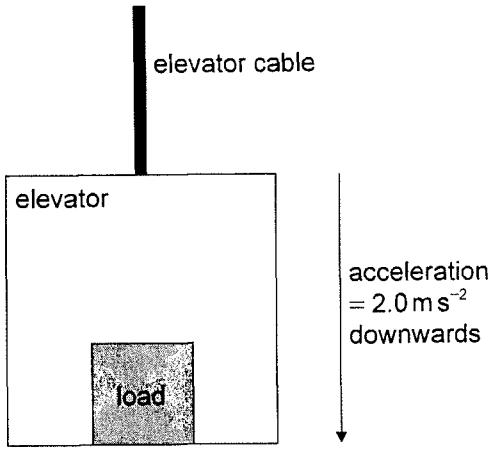
A. 0

B. $\frac{F}{2}$

C. F

D. $2F$

6. An elevator (lift) and its load have a total mass of 750 kg and accelerate vertically downwards at $2.0\,m\,s^{-2}$.



What is the tension in the elevator cable?

A. 1.5 kN

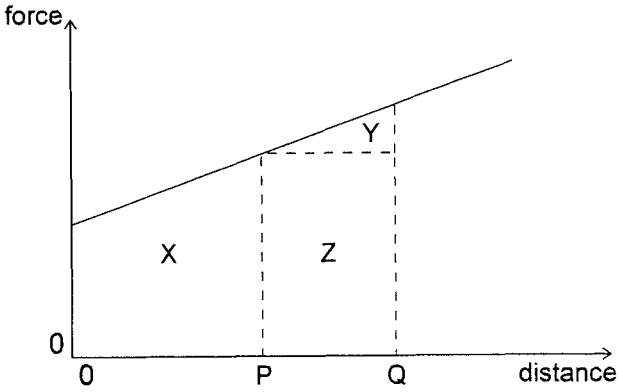
B. 6.0 kN

C. 7.5 kN

D. 9.0 kN

7. A graph shows the variation of force acting on an object moving in a straight line with distance moved by the object.

Which area represents the work done on the object during its motion from P to Q?



A. X

B. Y

C. Y + Z

D. X + Y + Z

8. A car travelling at a constant velocity covers a distance of 100 m in 5.0 s. The thrust of the engine is 1.5 kN.

What is the power of the car?

A. 0.75 kW

B. 3.0 kW

C. 7.5 kW

D. 30 kW

9. An inelastic collision occurs between two bodies in the absence of external forces.

What must be true about the total momentum of the two bodies and the total kinetic energy of the two bodies during this interaction?

A. Only momentum is conserved.

B. Only kinetic energy is conserved.

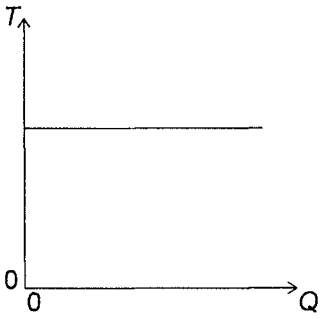
C. Both momentum and kinetic energy are conserved.

D. Neither momentum nor kinetic energy are conserved.

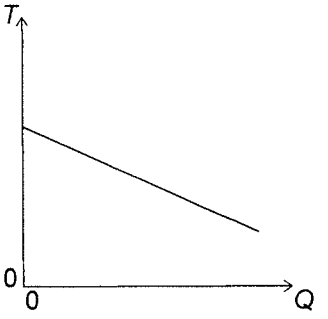
10. A liquid is initially at its freezing point. Energy is removed at a uniform rate from the liquid until it freezes completely.

Which graph shows how the temperature T of the liquid varies with the energy Q removed from the liquid?

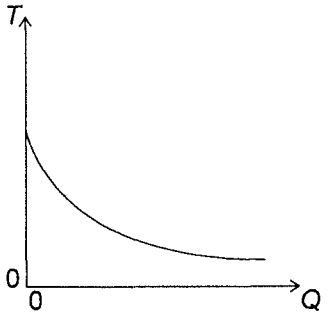
A.



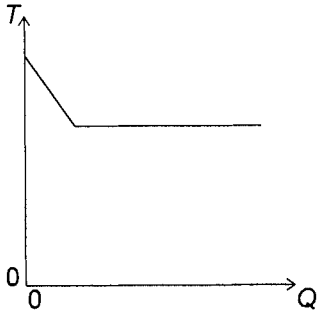
B.



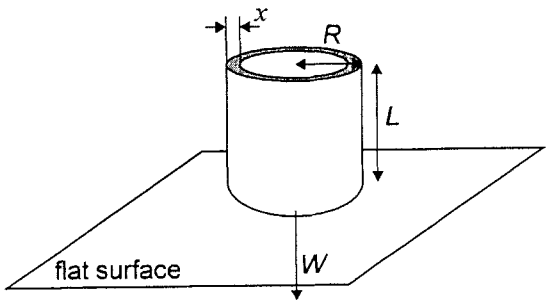
C.



D.



11. A thin-walled cylinder of weight W, open at both ends, rests on a flat surface. The cylinder has a height L, an average radius R and a thickness x where R is much greater than x.



What is the pressure exerted by the cylinder walls on the flat surface?

A. $\frac{W}{2\pi Rx}$

B. $\frac{W}{\pi R^2 x}$

C. $\frac{W}{\pi R^2}$

D. $\frac{W}{\pi R^2 L}$

12. A fixed mass of an ideal gas in a closed container with a movable piston initially occupies a volume V. The position of the piston is changed, so that the mean kinetic energy of the particles in the gas is doubled and the pressure remains constant.

What is the new volume of the gas?

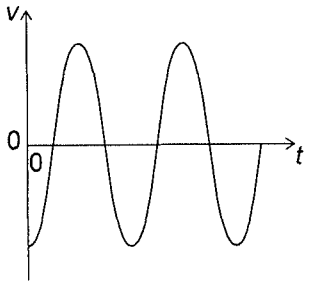
A. $\frac{V}{4}$

B. $\frac{V}{2}$

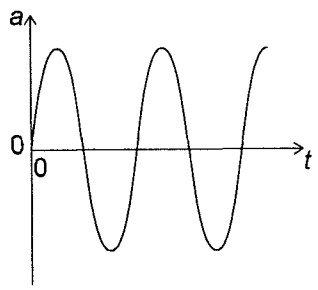
C. $2V$

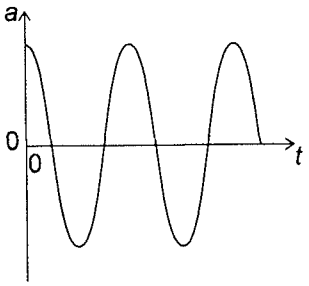
D. $4V$

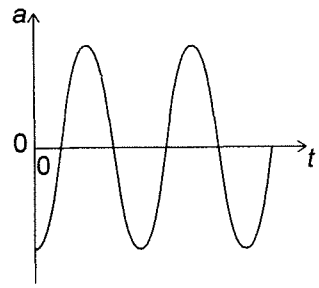
13. A particle undergoes simple harmonic motion (SHM). The graph shows the variation of velocity v of the particle with time t.

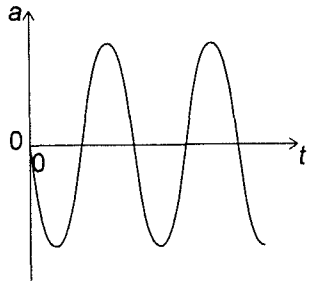


What is the variation with time of the acceleration a of the particle?

A.


B.


C.


D.


14. What statement about X-rays and ultraviolet radiation is correct?

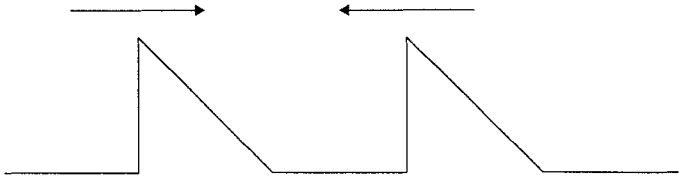
A. X-rays travel faster in a vacuum than ultraviolet waves.

B. X-rays have a higher frequency than ultraviolet waves.

C. X-rays cannot be diffracted unlike ultraviolet waves.

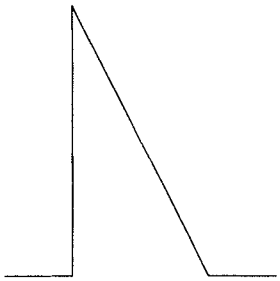
D. Microwaves lie between X-rays and ultraviolet in the electromagnetic spectrum.

15. Two pulses are travelling towards each other.

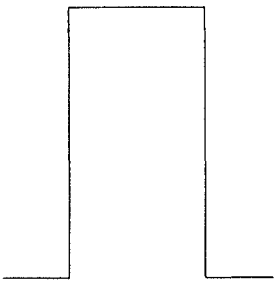


What is a possible pulse shape when the pulses overlap?

A.

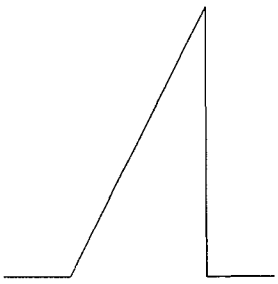


B.



C.

D.

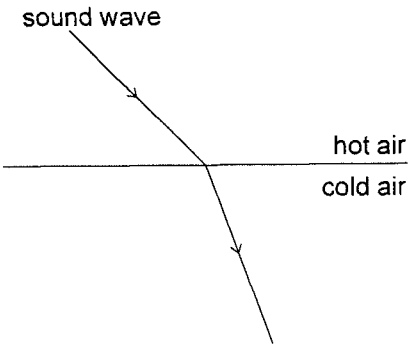


16. Unpolarized light of intensity I_0 is incident on the first of two polarizing sheets. Initially the planes of polarization of the sheets are perpendicular.

Which sheet must be rotated and by what angle so that light of intensity $\frac{I_0}{4}$ can emerge from the second sheet?

	Rotated sheet	Angle of rotation
A.	1 only	$\cos^{-1}\frac{\sqrt{2}}{2}$
B.	2 only	$\cos^{-1}\frac{1}{2}$
C.	1 or 2	$\cos^{-1}\frac{\sqrt{2}}{2}$
D.	1 or 2	$\cos^{-1}\frac{1}{2}$

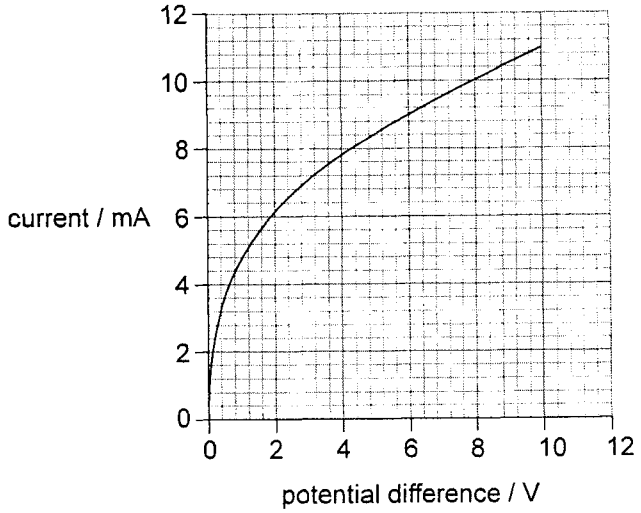
17. When a sound wave travels from a region of hot air to a region of cold air, it refracts as shown.



What changes occur in the frequency and wavelength of the sound as it passes from the hot air to the cold air?

	Frequency	Wavelength
A.	unchanged	increases
B.	unchanged	decreases
C.	increases	increases
D.	decreases	decreases

18. The graph shows the variation of current with potential difference for a filament lamp.



What is the resistance of the filament when the potential difference across it is 6.0 V?

A. 0.5 mΩ

B. 1.5 mΩ

C. 670 Ω

D. 2000 Ω

19. An electron is accelerated through a potential difference of 2.5 MV. What is the change in kinetic energy of the electron?

A. 0.4 μJ

B. 0.4 nJ

C. 0.4 pJ

D. 0.4 fJ

20. A cell is connected in series with a resistor and supplies a current of 4.0 A for a time of 500 s. During this time, 1.5 kJ of energy is dissipated in the cell and 2.5 kJ of energy is dissipated in the resistor.

What is the emf of the cell?

A. 0.50 V

B. 0.75 V

C. 1.5 V

D. 2.0 V

21. An electron travelling at speed v perpendicular to a magnetic field of strength B experiences a force F.

What is the force acting on an alpha particle travelling at $2v$ parallel to a magnetic field of strength $2B$?

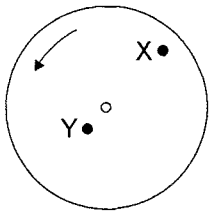
A. 0

B. $2F$

C. $4F$

D. $8F$

22. A horizontal disc rotates uniformly at a constant angular velocity about a central axis normal to the plane of the disc.



Point X is a distance $2L$ from the centre of the disc. Point Y is a distance L from the centre of the disc. Point Y has a linear speed v and a centripetal acceleration a.

What is the linear speed and centripetal acceleration of point X?

	Linear speed of X	Centripetal acceleration of X
A.	v	a
B.	$2v$	$2a$
C.	v	$2a$
D.	$2v$	$4a$

23. An object of constant mass is tied to the end of a rope of length l and made to move in a horizontal circle. The speed of the object is increased until the rope breaks at speed v. The length of the rope is then changed. At what other combination of rope length and speed will the rope break?

	Rope length	Speed
A.	$4l$	$2v$
B.	$2l$	v
C.	$2l$	$\frac{v}{2}$
D.	$4l$	$\frac{v}{2}$

24. A nucleus of phosphorus (P) decays to a nucleus of silicon (Si) with the emission of particle X and particle Y.

$$^{30}_{15}P \rightarrow {}^{30}_{14}Si + X + Y$$

What are X and Y?

	X	Y
A.	antineutrino	positron
B.	antineutrino	electron
C.	neutrino	electron
D.	neutrino	positron

25. What is the definition of the unified atomic mass unit?

A. $\frac{1}{12}$ the mass of a neutral atom of carbon-12

B. The mass of a neutral atom of hydrogen-1

C. $\frac{1}{12}$ the mass of a nucleus of carbon-12

D. The mass of a nucleus of hydrogen-1

26. In nuclear fission, a nucleus of element X absorbs a neutron (n) to give a nucleus of element Y and a nucleus of element Z.

$$X + n \rightarrow Y + Z + 2n$$

What is $\frac{\text{magnitude of the binding energy per nucleon of Y}}{\text{magnitude of the binding energy per nucleon of X}}$ and $\frac{\text{total binding energy of Y and Z}}{\text{total binding energy of X}}$?

	$\frac{\textbf{Magnitude of the binding energy per nucleon of Y}}{\textbf{Magnitude of the binding energy per nucleon of X}}$	$\frac{\textbf{Total binding energy of Y and Z}}{\textbf{Total binding energy of X}}$
A.	greater than 1	greater than 1
B.	less than 1	greater than 1
C.	greater than 1	less than 1
D.	less than1	less than 1

27. What is the energy equivalent to the mass of one proton?

A. $9.38 \times (3 \times 10^8)^2 \times 10^6\,\text{J}$

B. $9.38 \times (3 \times 10^8)^2 \times 1.6 \times 10^{-19}\,\text{J}$

C. $\frac{9.38 \times 10^8}{1.6 \times 10^{-19}}\,\text{J}$

D. $9.38 \times 10^8 \times 1.6 \times 10^{-19}\,\text{J}$

28. The following are energy sources.

I. a battery of rechargeable electric cells

II. crude oil

III. a pumped storage hydroelectric system

Which of these are secondary energy sources?

A. I and II only

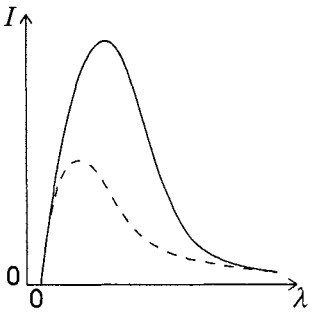
B. I and III only

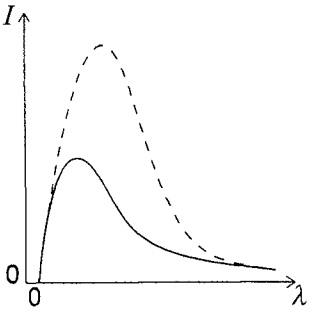
C. II and III only

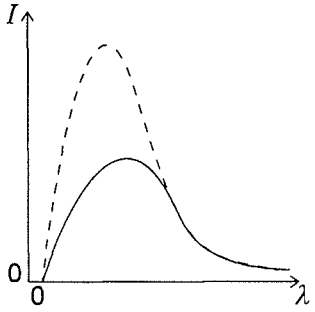
D. I, II and III

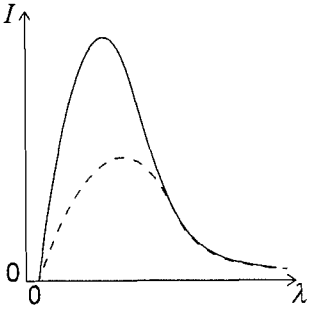
29. Planet X and planet Y both emit radiation as black bodies. Planet X has a surface temperature that is less than the surface temperature of planet Y.

What is the graph of the variation of intensity I with wavelength λ for the radiation emitted by planet Y? The graph for planet X is shown dotted.

A.


B.


C.


D.


30. The average surface temperature of Mars is approximately 200 K and the average surface temperature of Earth is approximately 300 K. Mars has a radius half that of Earth. Assume that both Mars and Earth act as black bodies.

What is $\frac{\text{power radiated by Mars}}{\text{power radiated by Earth}}$?

A. 20

B. 5

C. 0.2

D. 0.05

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

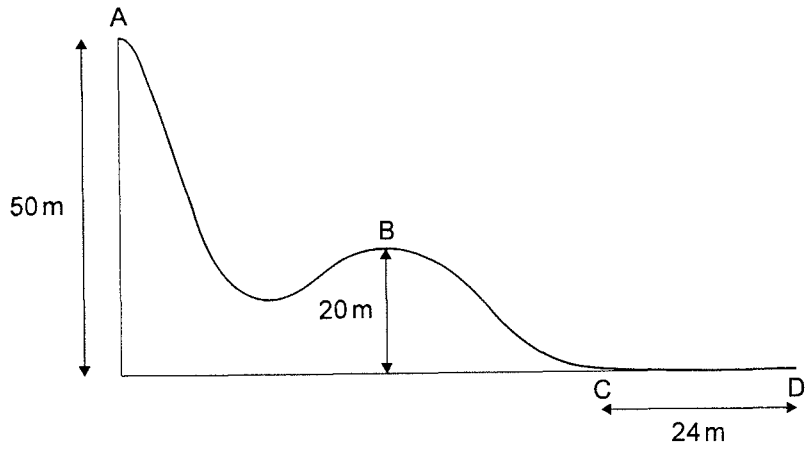
Instructions to candidates

- 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]**.

2217–6511

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]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(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]

. . . . . .

. . . . . .

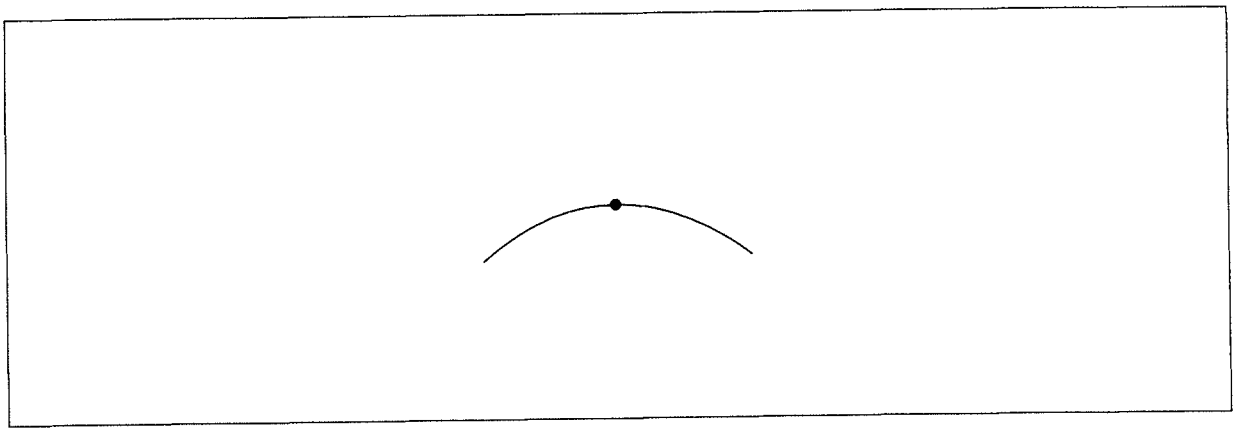
. . . . . .

. . . . . .

(This question continues on the following page)

(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]



(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]

.....

.....

.....

.....

.....

.....

(c) The skier reaches point C with a speed of $8.2\,m\,s^{-1}$. 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]

.....

.....

.....

.....

.....

.....

(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]

.....

.....

.....

.....

(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]

.....

.....

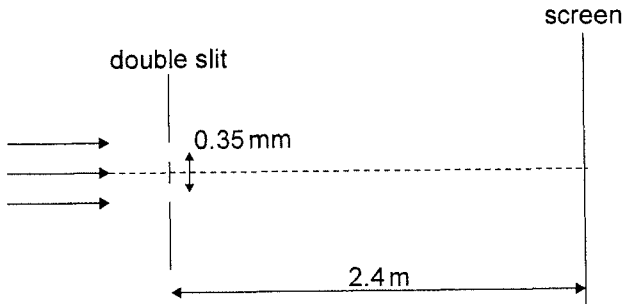
.....

.....

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

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(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]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(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]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(d) One of the slits is now covered.

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

. . . . . .
. . . . . .
. . . . . .
. . . . . .

3. Two renewable energy sources are solar and wind.

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

.....

.....

(b) A solar farm is made up of photovoltaic cells of area 25 000 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]

.....

.....

.....

.....

(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]

.....

.....

.....

.....

.....

.....

(This question continues on the following page)

(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]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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]

. . . . . .
. . . . . .

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

. . . . . .
. . . . . .
. . . . . .
. . . . . .

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

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(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]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

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

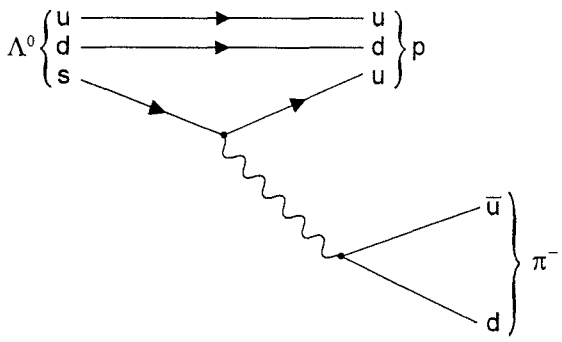
Meson: .....

.....

Baryon: .....

.....

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



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

.....

.....

.....

.....

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

(This question continues on the following page)

(Question 5 continued)

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

.....

.....

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

.....

.....

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 3

Tuesday 16 May 2017 (morning)

1 hour

Candidate session number

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- 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 **[35 marks]**.

Section A	Questions
Answer all questions.	1 – 2

Section B	Questions
Answer all of the questions from one of the options.	
Option A — Relativity	3 – 4
Option B — Engineering physics	5 – 6
Option C — Imaging	7 – 8
Option D — Astrophysics	9 – 10

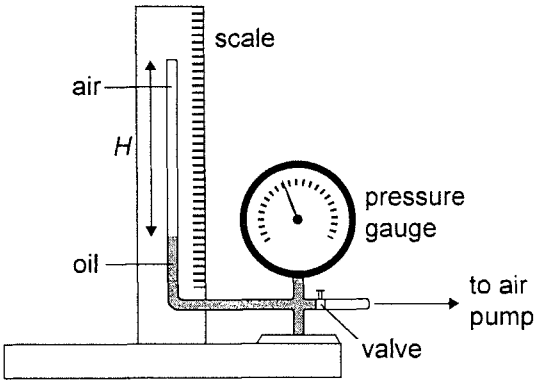
2217–6512

25 pages

Section A

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

1. The equipment shown in the diagram was used by a student to investigate the variation with volume, of the pressure p of air, at constant temperature. The air was trapped in a tube of constant cross-sectional area above a column of oil.



The pump forces oil to move up the tube decreasing the volume of the trapped air.

(a) The student measured the height H of the air column and the corresponding air pressure p. After each reduction in the volume the student waited for some time before measuring the pressure. Outline why this was necessary. [1]

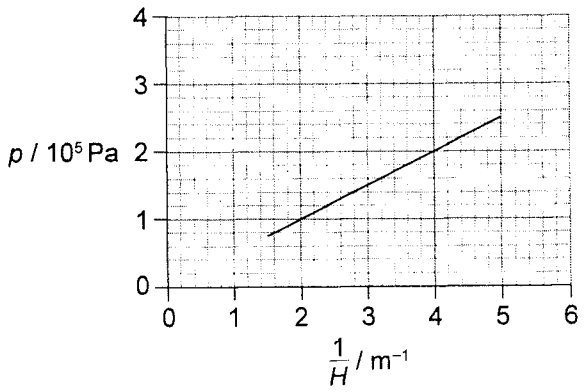
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) The following graph of p versus $\frac{1}{H}$ was obtained. Error bars were negligibly small.



The equation of the line of best fit is $p = a + \frac{b}{H}$.

Determine the value of b including an appropriate unit. [3]

.....

.....

.....

.....

.....

.....

(c) Outline how the results of this experiment are consistent with the ideal gas law at constant temperature. [2]

.....

.....

.....

.....

(This question continues on the following page)

(Question 1 continued)

(d) The cross-sectional area of the tube is $1.3 \times 10^{-3}\,m^2$ and the temperature of air is 300 K. Estimate the number of moles of air in the tube. [2]

.....

.....

.....

.....

(e) The equation in (b) may be used to predict the pressure of the air at extremely large values of $\frac{1}{H}$. Suggest why this will be an unreliable estimate of the pressure. [2]

.....

.....

.....

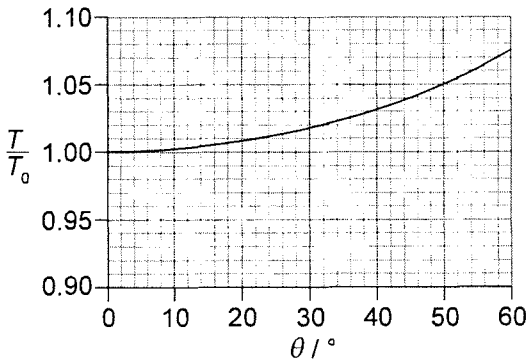
.....

2. (a) In a simple pendulum experiment, a student measures the period T of the pendulum many times and obtains an average value $T = (2.540 \pm 0.005)$ s. The length L of the pendulum is measured to be $L = (1.60 \pm 0.01)$ m.

Calculate, using $g = \frac{4\pi^2 L}{T^2}$, the value of the acceleration of free fall, including its uncertainty. State the value of the uncertainty to one significant figure. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) In a different experiment a student investigates the dependence of the period T of a simple pendulum on the amplitude of oscillations θ. The graph shows the variation of $\frac{T}{T_0}$ with θ, where T_0 is the period for small amplitude oscillations.



The period may be considered to be independent of the amplitude θ as long as $\frac{T - T_0}{T_0} < 0.01$. Determine the maximum value of θ for which the period is independent of the amplitude. [2]

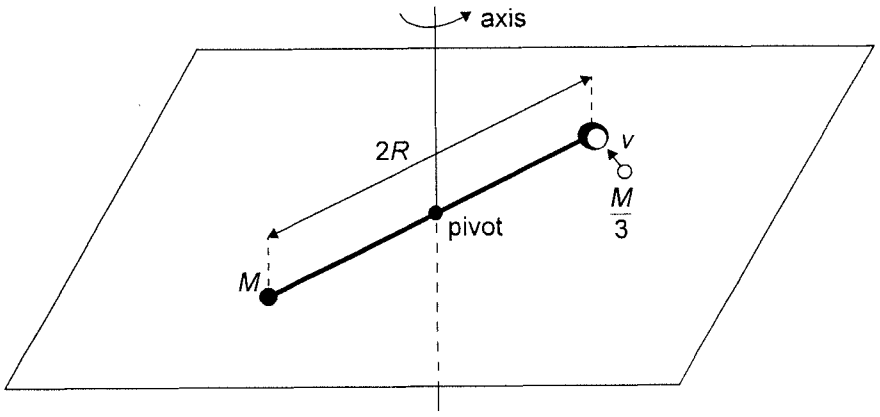
. . . . . .
. . . . . .
. . . . . .
. . . . . .

Option B — Engineering physics

5. A horizontal rigid bar of length $2R$ is pivoted at its centre. The bar is free to rotate in a horizontal plane about a vertical axis through the pivot. A point particle of mass M is attached to one end of the bar and a container is attached to the other end of the bar.

A point particle of mass $\frac{M}{3}$ moving with speed v at right angles to the rod collides with the container and gets stuck in the container. The system then starts to rotate about the vertical axis.

The mass of the rod and the container can be neglected.



(a) (i) Write down an expression, in terms of M, v and R, for the angular momentum of the system about the vertical axis just before the collision. [1]

. . . . . .

. . . . . .

(ii) Just after the collision the system begins to rotate about the vertical axis with angular velocity ω. Show that the angular momentum of the system is equal to $\frac{4}{3}MR^2\omega$. [1]

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B, question 5 continued)

(iii) Hence, show that $\omega = \frac{v}{4R}$. [1]

. . . . . .
. . . . . .

(iv) Determine in terms of M and v the energy lost during the collision. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) A torque of 0.010 N m brings the system to rest after a number of revolutions. For this case $R = 0.50\,\text{m}$, $M = 0.70\,\text{kg}$ and $v = 2.1\,\text{m s}^{-1}$.

(i) Show that the angular deceleration of the system is $0.043\,\text{rad s}^{-2}$. [1]

. . . . . .
. . . . . .

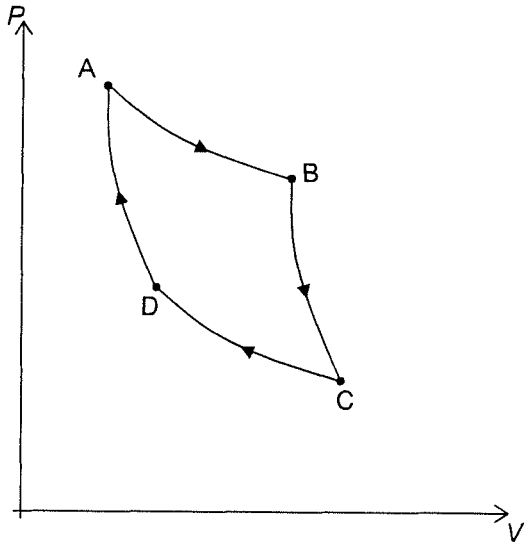
(ii) Calculate the number of revolutions made by the system before it comes to rest. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option B continues on the following page)

(Option B continued)

6. The *P*–*V* diagram of the Carnot cycle for a monatomic ideal gas is shown.



(a) State what is meant by an adiabatic process. [1]

. . . . . .
. . . . . .

(b) Identify the two isothermal processes. [1]

. . . . . .
. . . . . .

(c) The system consists of 0.150 mol of a gas initially at A. The pressure at A is 512 kPa and the volume is $1.20 \times 10^{-3}\,m^3$.

(i) Determine the temperature of the gas at A. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(Option B continues on the following page)

(Option B, question 6 continued)

(ii) The volume at B is $2.30 \times 10^{-3}\,m^3$. Determine the pressure at B. [2]

(d) At C the volume is V_C and the temperature is T_C.

(i) Show that $P_B V_B^{\frac{5}{3}} = nRT_C V_C^{\frac{2}{3}}$. [1]

(ii) The volume at C is $2.90 \times 10^{-3}\,m^3$. Calculate the temperature at C. [2]

(e) State a reason why a Carnot cycle is of little use for a practical heat engine. [1]

End of Option B

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 1

Thursday 10 May 2018 (afternoon)

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[30 marks]**.

2218–6510

1. A student measures the radius r of a sphere with an absolute uncertainty Δr. What is the fractional uncertainty in the volume of the sphere?

A. $\left(\frac{\Delta r}{r}\right)^3$

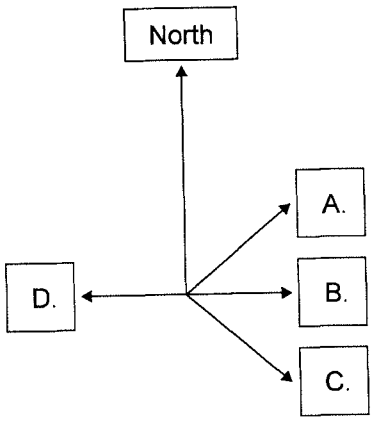
B. $3\frac{\Delta r}{r}$

C. $4\pi\frac{\Delta r}{r}$

D. $4\pi\left(\frac{\Delta r}{r}\right)^3$

2. A river flows north. A boat crosses the river so that it only moves in the direction east of its starting point.

What is the direction in which the boat must be steered?



3. An object is projected vertically upwards at time $t = 0$. Air resistance is negligible. The object passes the same point above its starting position at times 2 s and 8 s.

If g = 10 m s^{-2}, what is the initial speed of the object?

A. 50

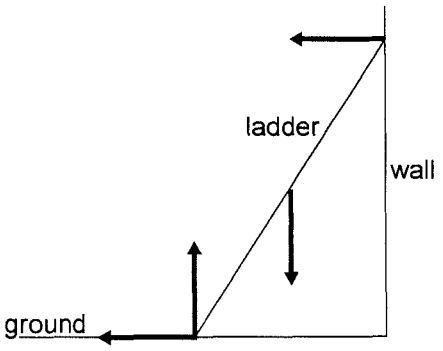
B. 30

C. 25

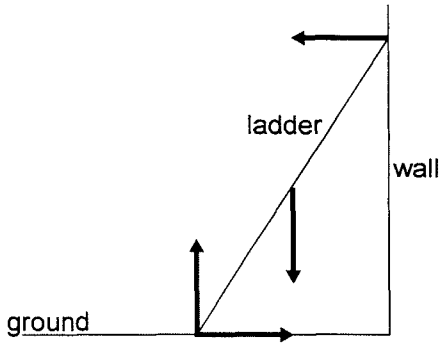
D. 4

4. A uniform ladder resting in equilibrium on rough ground leans against a smooth wall. Which diagram correctly shows the forces acting on the ladder?

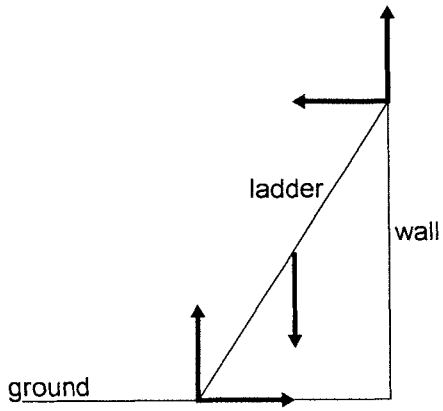
A.



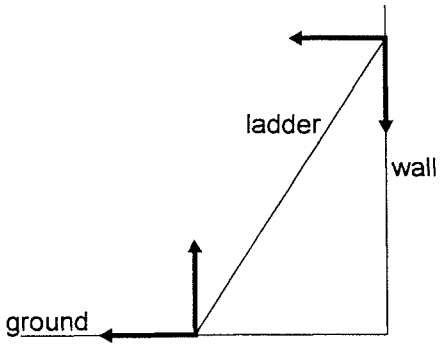
B.



C.



D.



5. An object falls from rest from a height h close to the surface of the Moon. The Moon has no atmosphere.

When the object has fallen to height $\frac{h}{4}$ above the surface, what is

$$\frac{\text{kinetic energy of the object at } \frac{h}{4}}{\text{gravitational potential energy of the object at } h} ?$$

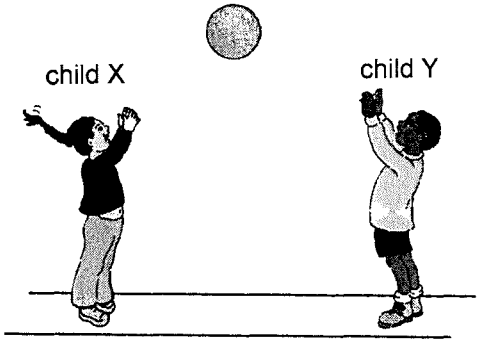
A. $\frac{3}{4}$

B. $\frac{4}{3}$

C. $\frac{9}{16}$

D. $\frac{16}{9}$

6. Child X throws a ball to child Y. The system consists of the ball, the children and the Earth. What is true for the system when the ball has been caught by Y?



[Source: https://pixabay.com/en/playing-ball-kids-boy-girl-31339/]

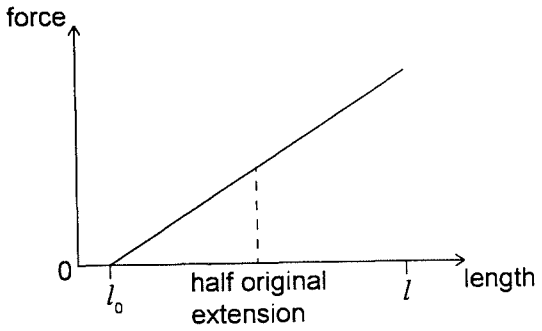
A. The momentum of child Y is equal and opposite to the momentum of child X.

B. The speed of rotation of the Earth will have changed.

C. The ball has no net momentum while it is in the air.

D. The total momentum of the system has not changed.

7. An increasing force acts on a metal wire and the wire extends from an initial length l_0 to a new length l. The graph shows the variation of force with length for the wire. The energy required to extend the wire from l_0 to l is E.



The wire then contracts to half its original extension.

What is the work done by the wire as it contracts?

A. $0.25E$

B. $0.50E$

C. $0.75E$

D. E

8. The distances between successive positions of a moving car, measured at equal time intervals, are shown.

diagram not to scale

The car moves with

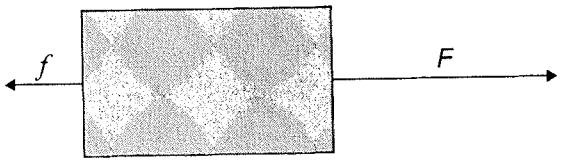
A. acceleration that increases linearly with time.

B. acceleration that increases non-linearly with time.

C. constant speed.

D. constant acceleration.

9. An object is moving in a straight line. A force F and a resistive force f act on the object along the straight line.



Both forces act for a time t.

What is the rate of change of momentum with time of the object during time t?

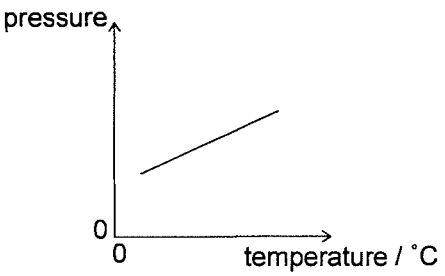
A. $F+f$

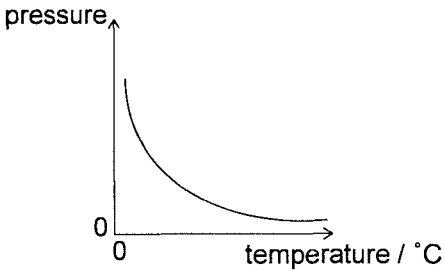
B. $F-f$

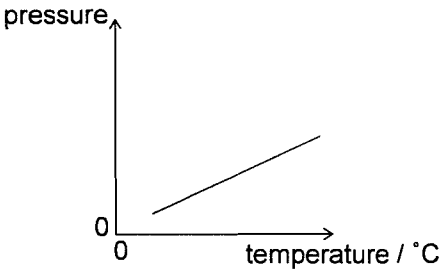
C. $(F+f)t$

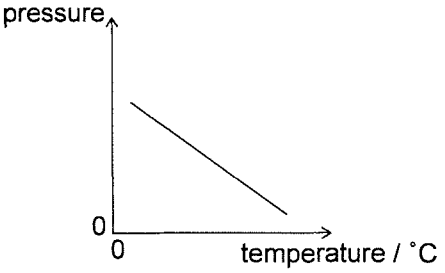
D. $(F-f)t$

10. A fixed mass of an ideal gas is trapped in a cylinder of constant volume and its temperature is varied. Which graph shows the variation of the pressure of the gas with temperature in degrees Celsius?

A.


B.


C.


D.


11. What are the units of the ratio $\frac{\text{specific heat capacity of copper}}{\text{specific latent heat of vaporization of copper}}$?

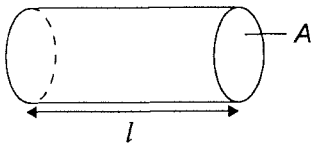
A. no units

B. k

C. k^{-1}

D. k^{-2}

12. A sealed cylinder of length l and cross-sectional area A contains N molecules of an ideal gas at kelvin temperature T.



What is the force acting on the area of the cylinder marked A due to the gas?

A. $\frac{NRT}{l}$

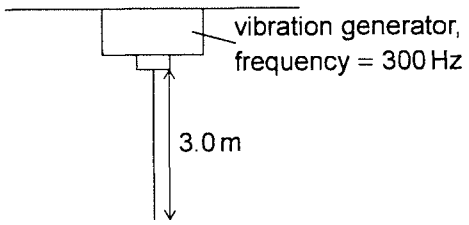
B. $\frac{NRT}{lA}$

C. $\frac{Nk_BT}{lA}$

D. $\frac{Nk_BT}{l}$

13. A first-harmonic standing wave is formed on a vertical string of length 3.0 m using a vibration generator. The boundary conditions for this string are that it is fixed at one boundary and free at the other boundary.

diagram not to scale



The generator vibrates at a frequency of 300 Hz.

What is the speed of the wave on the string?

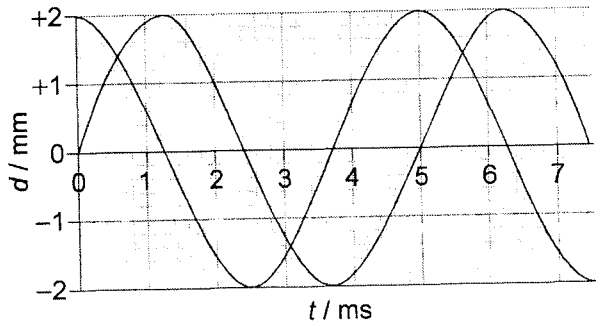
A. $0.90\,\text{km s}^{-1}$

B. $1.2\,\text{km s}^{-1}$

C. $1.8\,\text{km s}^{-1}$

D. $3.6\,\text{km s}^{-1}$

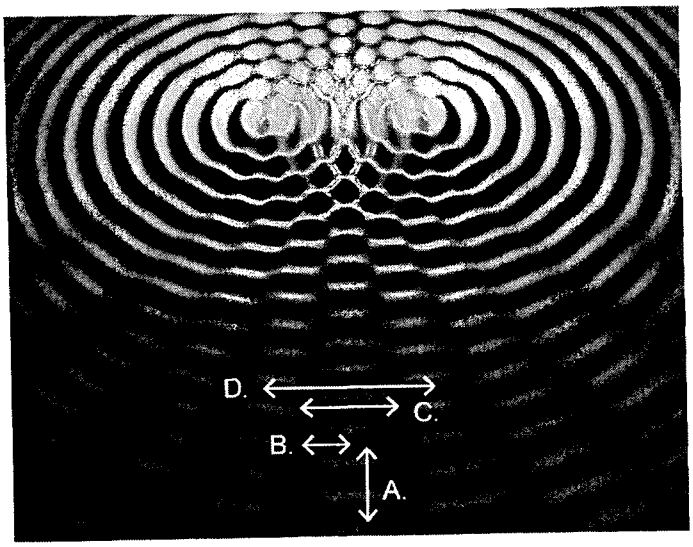
14. Two travelling waves are moving through a medium. The diagram shows, for a point in the medium, the variation with time t of the displacement d of each of the waves.



For the instant when $t = 2.0\,\text{ms}$, what is the phase difference between the waves and what is the resultant displacement of the waves?

	Phase difference	Resultant displacement / mm
A.	45°	−0.6
B.	90°	2.6
C.	45°	2.6
D.	90°	−0.6

15. The diagram shows an interference pattern produced by two sources that oscillate on the surface of a liquid.



[Source: Science Photo Library www.sciencephoto.com]

Which of the distances shown in the diagram corresponds to **one** fringe width of the interference pattern?

16. A system that is subject to a restoring force oscillates about an equilibrium position.

For the motion to be simple harmonic, the restoring force must be proportional to

A. the amplitude of the oscillation.

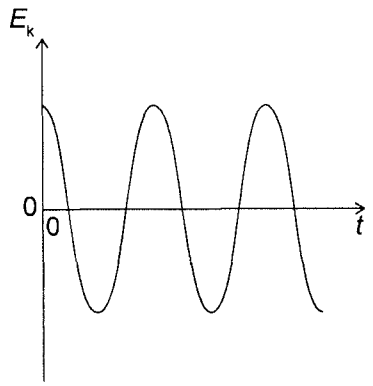
B. the displacement from the equilibrium position.

C. the potential energy of the system.

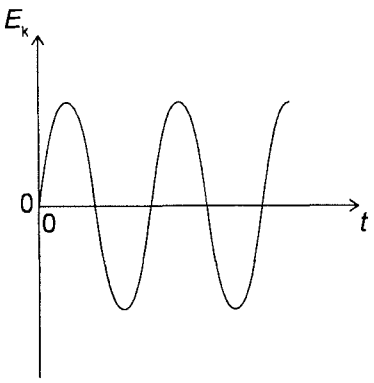
D. the period of the oscillation.

17. A particle is displaced from rest and released at time $t = 0$. It performs simple harmonic motion (SHM). Which graph shows the variation with time of the kinetic energy E_k of the particle?

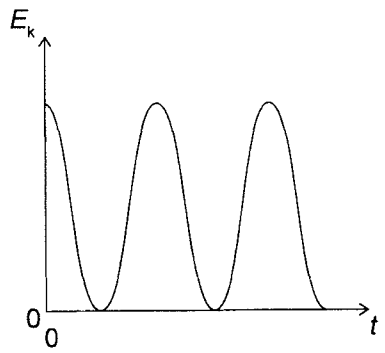
A.



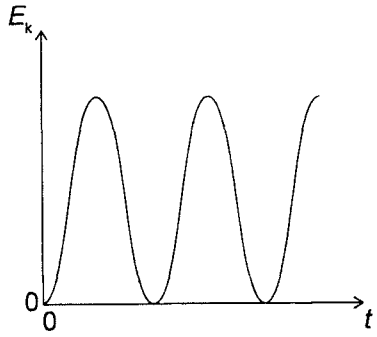
B.



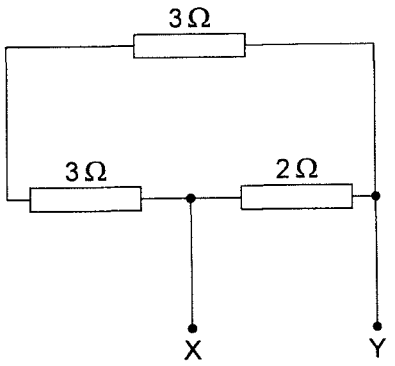
C.



D.



18. Three resistors are connected as shown. What is the value of the total resistance between X and Y?



A. 1.5Ω

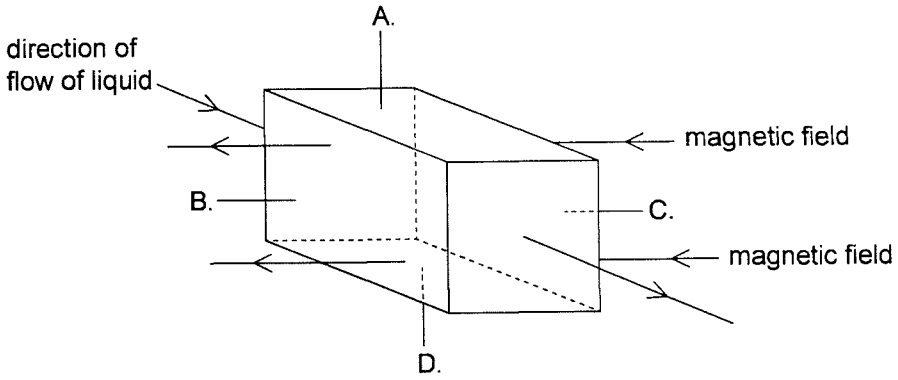
B. 1.9Ω

C. 6.0Ω

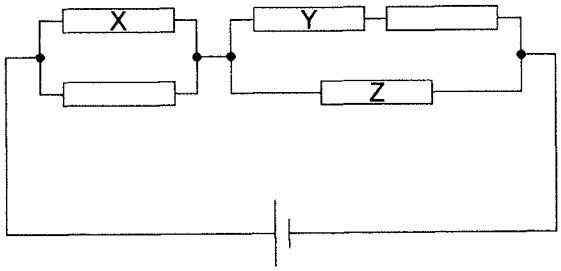
D. 8.0Ω

19. A liquid that contains negative charge carriers is flowing through a square pipe with sides A, B, C and D. A magnetic field acts in the direction shown across the pipe.

On which side of the pipe does negative charge accumulate?



20. Five resistors of equal resistance are connected to a cell as shown.



What is correct about the power dissipated in the resistors?

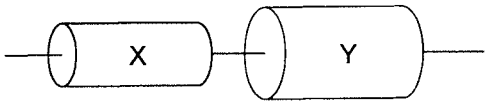
A. The power dissipated is greatest in resistor X.

B. The power dissipated is greatest in resistor Y.

C. The power dissipated is greatest in resistor Z.

D. The power dissipated is the same in all resistors.

21. Two resistors X and Y are made of uniform cylinders of the same material. X and Y are connected in series. X and Y are of equal length and the diameter of Y is twice the diameter of X.



The resistance of Y is R.

What is the resistance of this series combination?

A. $\frac{5R}{4}$

B. $\frac{3R}{2}$

C. $3R$

D. $5R$

22. An object of mass m at the end of a string of length r moves in a vertical circle at a constant angular speed ω.

What is the tension in the string when the object is at the bottom of the circle?

A. $m(\omega^2 r + g)$

B. $m(\omega^2 r - g)$

C. $mg(\omega^2 r + 1)$

D. $mg(\omega^2 r - 1)$

23. Newton's law of gravitation

A. is equivalent to Newton's second law of motion.

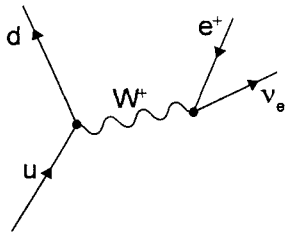
B. explains the origin of gravitation.

C. is used to make predictions.

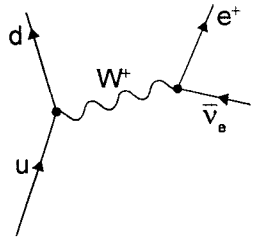
D. is not valid in a vacuum.

24. Which Feynman diagram shows beta-plus (β^+) decay?

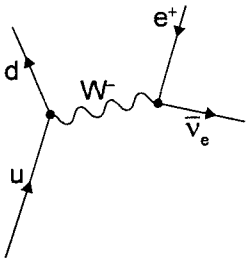
A.



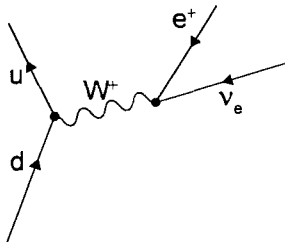
B.



C.



D.



25. The average binding energy per nucleon of the $^{15}_{8}O$ nucleus is 7.5 MeV. What is the total energy required to separate the nucleons of one nucleus of $^{15}_{8}O$?

A. 53 MeV

B. 60 MeV

C. 113 MeV

D. 173 MeV

26. Two pure samples of radioactive nuclides X and Y have the same initial number of atoms. The half-life of X is $T_{\frac{1}{2}}$.

After a time equal to 4 half-lives of X the ratio $\frac{\text{number of atoms of X}}{\text{number of atoms of Y}}$ is $\frac{1}{8}$.

What is the half-life of Y?

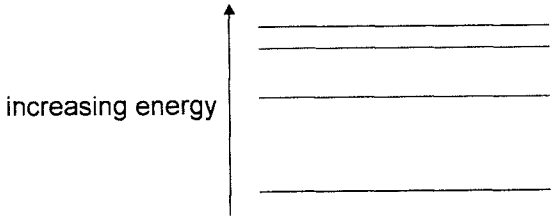
A. $0.25T_{\frac{1}{2}}$

B. $0.5T_{\frac{1}{2}}$

C. $3T_{\frac{1}{2}}$

D. $4T_{\frac{1}{2}}$

27. The energy-level diagram for an atom that has four energy states is shown.



What is the number of different wavelengths in the emission spectrum of this atom?

A. 1

B. 3

C. 6

D. 7

28. What is equivalent to $\frac{\text{specific energy of a fuel}}{\text{energy density of a fuel}}$?

A. density of the fuel

B. $\frac{1}{\text{density of the fuel}}$

C. $\frac{\text{energy stored in the fuel}}{\text{density of the fuel}}$

D. $\frac{\text{density of the fuel}}{\text{energy stored in the fuel}}$

29. Three energy sources for power stations are

I. fossil fuel
II. pumped water storage
III. nuclear fuel.

Which energy sources are primary sources?

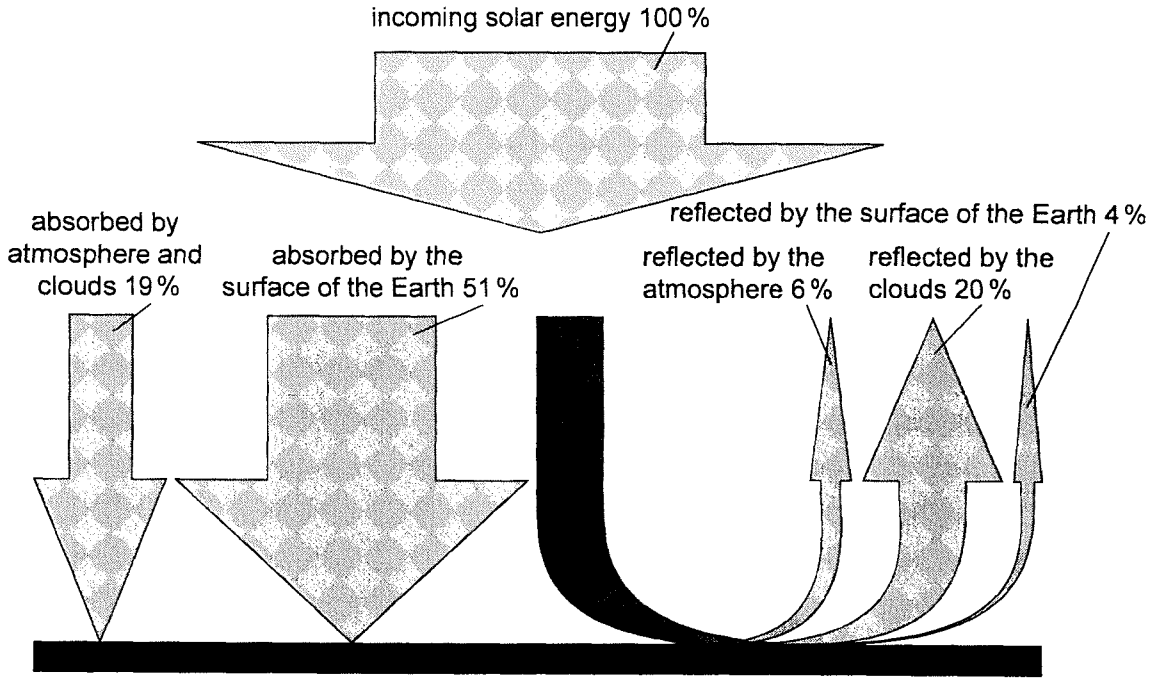
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

30. The diagram shows a simple climate model for the Earth.



What does this model predict for the average albedo of the Earth?

A. 0.30

B. 0.51

C. 0.70

D. 0.81

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Thursday 10 May 2018 (afternoon)

1 hour 15 minutes

Candidate session number

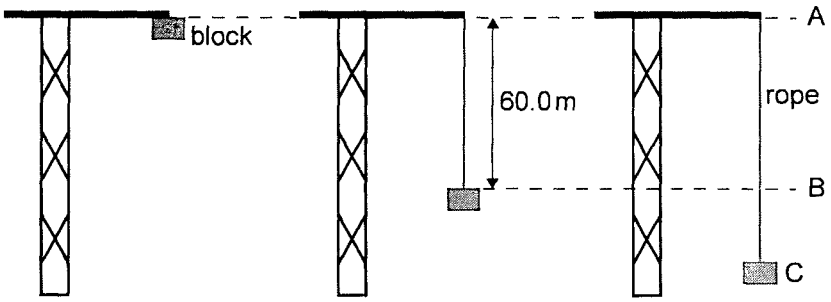
Instructions to candidates

- 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]**.

2218–6511

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

1. An elastic climbing rope is tested by fixing one end of the rope to the top of a crane. The other end of the rope is connected to a block which is initially at position A. The block is released from rest. The mass of the rope is negligible.



The unextended length of the rope is 60.0 m. From position A to position B, the block falls freely.

(a) At position B the rope starts to extend. Calculate the speed of the block at position B. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) At position C the speed of the block reaches zero. The time taken for the block to fall between B and C is 0.759 s. The mass of the block is 80.0 kg.

(i) Determine the magnitude of the average resultant force acting on the block between B and C. [2]

. . . . . .

. . . . . .

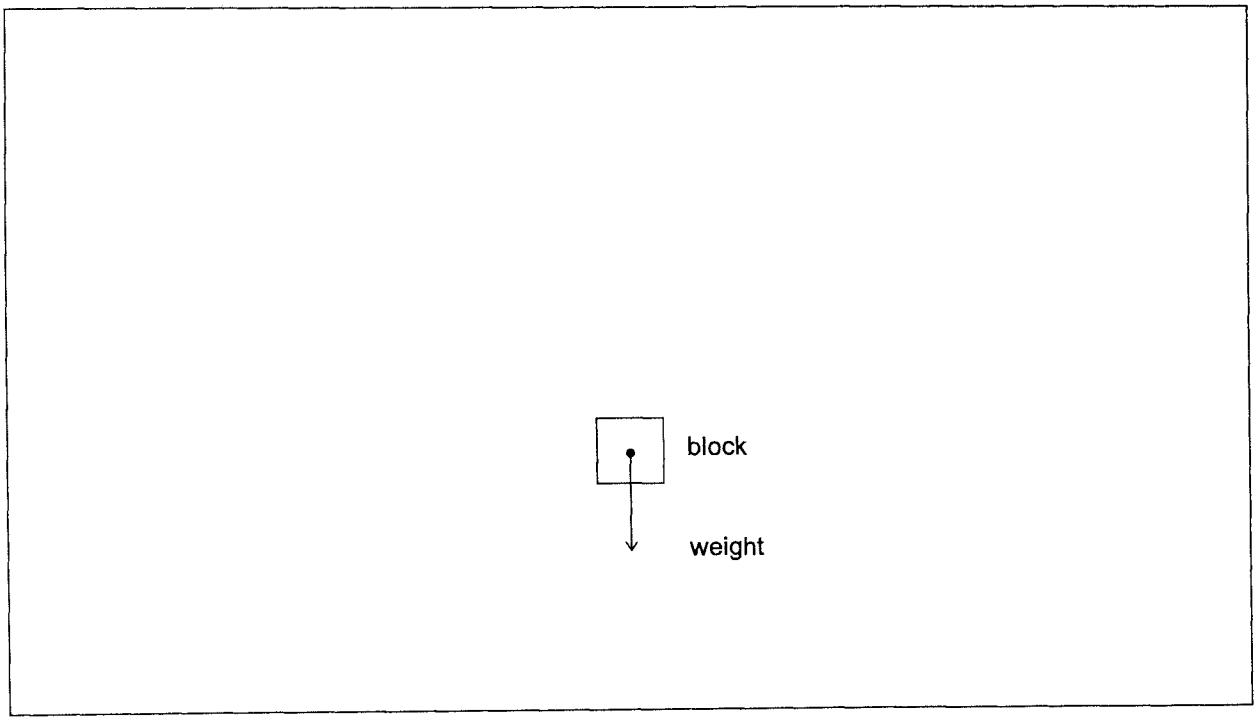
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(ii) Sketch on the diagram the average resultant force acting on the block between B and C. The arrow on the diagram represents the weight of the block. [2]



(iii) Calculate the magnitude of the average force exerted by the rope on the block between B and C. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) For the rope and block, describe the energy changes that take place

(i) between A and B. [1]

. . . . . .

. . . . . .

(ii) between B and C. [1]

. . . . . .

. . . . . .

(d) The length reached by the rope at C is 77.4 m. Suggest how energy considerations could be used to determine the elastic constant of the rope. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

2. A closed box of fixed volume $0.15\,m^3$ contains 3.0 mol of an ideal monatomic gas. The temperature of the gas is 290 K.

(a) Calculate the pressure of the gas. [1]

. . . . . .

. . . . . .

(b) When the gas is supplied with 0.86 kJ of energy, its temperature increases by 23 K. The specific heat capacity of the gas is $3.1\,kJ\,kg^{-1}K^{-1}$.

(i) Calculate, in kg, the mass of the gas. [1]

. . . . . .

. . . . . .

(ii) Calculate the average kinetic energy of the particles of the gas. [1]

. . . . . .

. . . . . .

(c) Explain, with reference to the kinetic model of an ideal gas, how an increase in temperature of the gas leads to an increase in pressure. [3]

. . . . . .

. . . . . .

. . . . . .

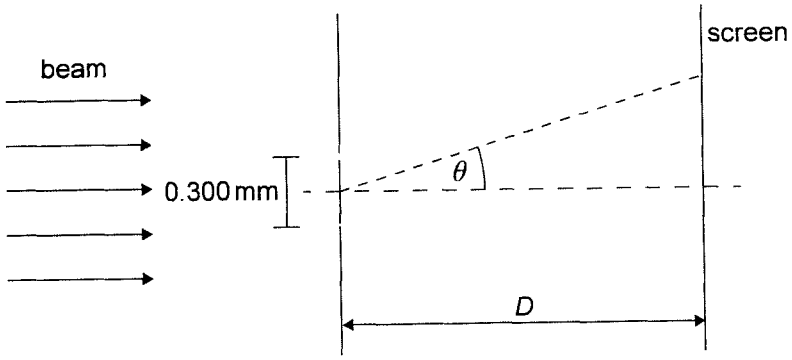
. . . . . .

. . . . . .

. . . . . .

3. A beam of coherent monochromatic light from a distant galaxy is used in an optics experiment on Earth.

(a) The beam is incident normally on a double slit. The distance between the slits is 0.300 mm. A screen is at a distance D from the slits. The diffraction angle θ is labelled.



(i) A series of dark and bright fringes appears on the screen. Explain how a dark fringe is formed. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(ii) The wavelength of the beam as observed on Earth is 633.0 nm. The separation between a dark and a bright fringe on the screen is 4.50 mm. Calculate D. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(Question 3 continued)

(b) The air between the slits and the screen is replaced with water. The refractive index of water is 1.33.

(i) Calculate the wavelength of the light in water. [1]

. . . . . .

. . . . . .

(ii) State **two** ways in which the intensity pattern on the screen changes. [2]

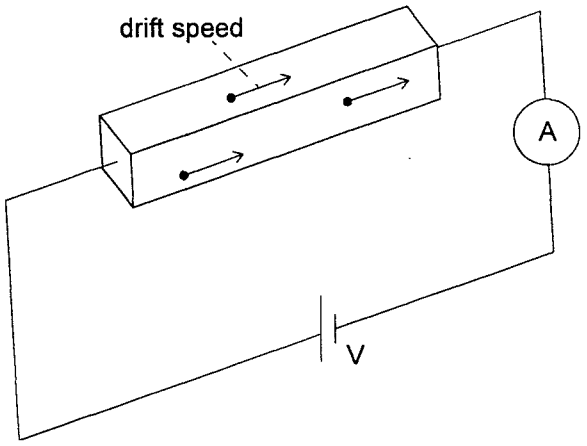
. . . . . .

. . . . . .

. . . . . .

. . . . . .

4. An ohmic conductor is connected to an ideal ammeter and to a power supply of output voltage V.



The following data are available for the conductor:

density of free electrons $= 8.5 \times 10^{22}\,\text{cm}^{-3}$
resistivity $\rho = 1.7 \times 10^{-8}\,\Omega\text{m}$
dimensions $w \times h \times l = 0.020\,\text{cm} \times 0.020\,\text{cm} \times 10\,\text{cm}$.

The ammeter reading is 2.0A.

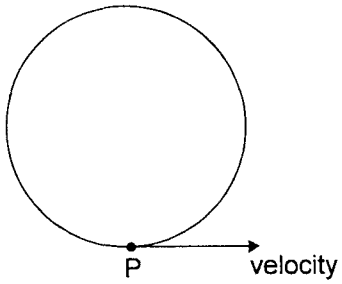
(a) Calculate the resistance of the conductor. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) Calculate the drift speed v of the electrons in the conductor in $\text{cm}\,\text{s}^{-1}$.
State your answer to an appropriate number of significant figures. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

5. An electron moves in circular motion in a uniform magnetic field.



The velocity of the electron at point P is $6.8 \times 10^5 \text{ m s}^{-1}$ in the direction shown.
The magnitude of the magnetic field is 8.5 T.

(a) State the direction of the magnetic field. [1]

. . . . . .
. . . . . .

(b) Calculate, in N, the magnitude of the magnetic force acting on the electron. [1]

. . . . . .
. . . . . .

(c) Explain why the electron moves

(i) at constant speed. [1]

. . . . . .
. . . . . .

(ii) on a circular path. [2]

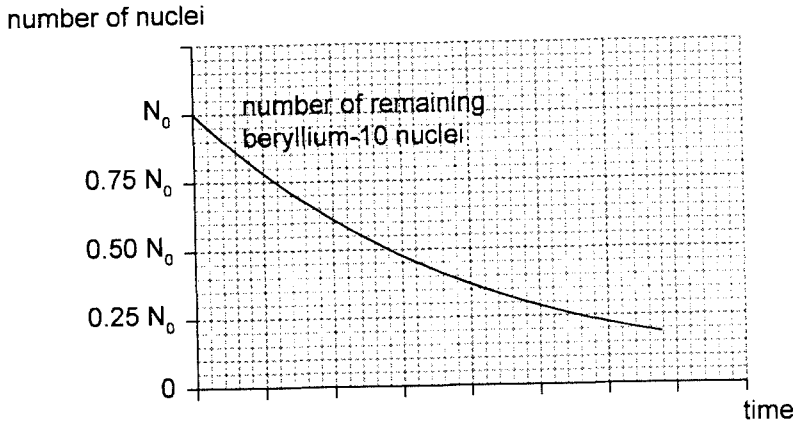
. . . . . .
. . . . . .
. . . . . .
. . . . . .

6. The radioactive nuclide beryllium-10 (Be-10) undergoes beta minus ($\beta-$) decay to form a stable boron (B) nuclide.

(a) Identify the missing information for this decay. [1]

$$^{10}\square\text{Be} \rightarrow {}^{\square}_{5}\text{B} + \beta + \overline{\upsilon}$$

(b) The initial number of nuclei in a pure sample of beryllium-10 is N_0. The graph shows how the number of remaining **beryllium** nuclei in the sample varies with time.



(i) On the graph, sketch how the number of **boron** nuclei in the sample varies with time. [2]

(ii) After 4.3×10^6 years,

$$\frac{\text{number of produced boron nuclei}}{\text{number of remaining beryllium nuclei}} = 7.$$

Show that the half-life of beryllium-10 is 1.4×10^6 years. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 6 continued)

(iii) Beryllium-10 is used to investigate ice samples from Antarctica. A sample of ice initially contains 7.6×10^{11} atoms of beryllium-10. State the number of remaining beryllium-10 nuclei in the sample after 2.8×10^{6} years. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 6 continued)

(c) An ice sample is moved to a laboratory for analysis. The temperature of the sample is –20 °C.

(i) State what is meant by thermal radiation. [1]

. . . . . .

. . . . . .

(ii) Discuss how the frequency of the radiation emitted by a black body can be used to estimate the temperature of the body. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iii) Calculate the peak wavelength in the intensity of the radiation emitted by the ice sample. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iv) Derive the units of intensity in terms of fundamental SI units. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 3

Friday 11 May 2018 (morning)

1 hour

Candidate session number

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- 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 **[35 marks]**.

Section A	Questions
Answer all questions.	1 – 2

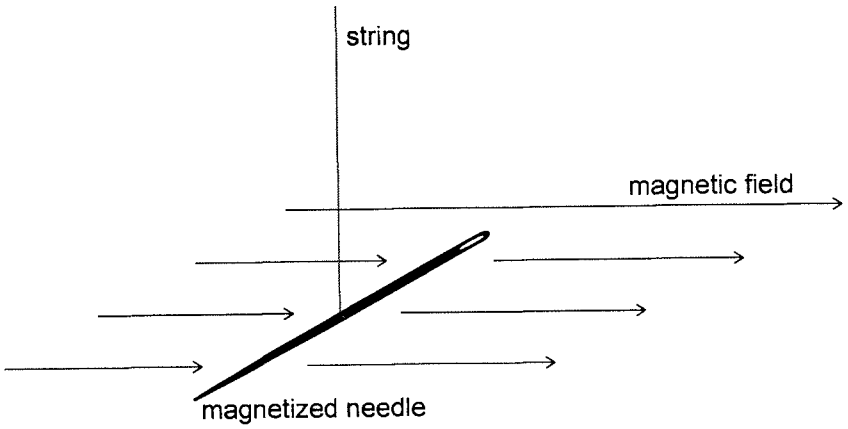
Section B	Questions
Answer all of the questions from one of the options.	
Option A — Relativity	3 – 5
Option B — Engineering physics	6 – 7
Option C — Imaging	8 – 9
Option D — Astrophysics	10 – 12

2218–6512

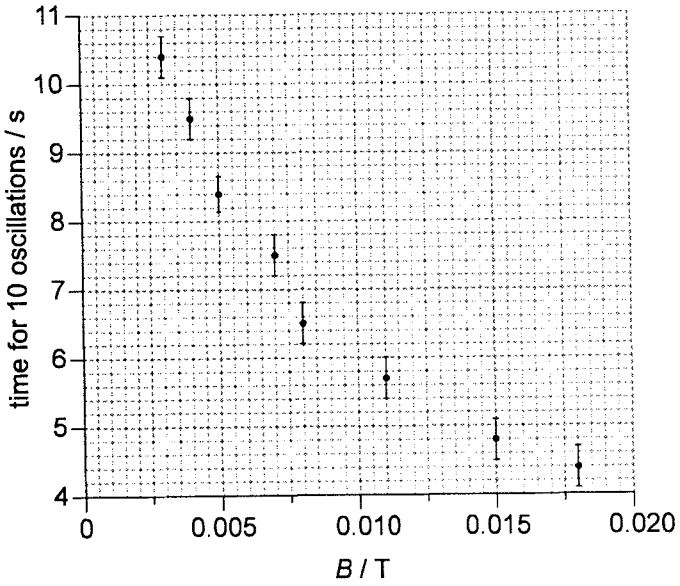
Section A

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

1. A magnetized needle is oscillating on a string about a vertical axis in a horizontal magnetic field *B*. The time for 10 oscillations is recorded for different values of *B*.



The graph shows the variation with *B* of the time for 10 oscillations together with the uncertainties in the time measurements. The uncertainty in *B* is negligible.



(a) Draw on the graph the line of best fit for the data. [1]

(This question continues on the following page)

(Question 1 continued)

(b) (i) Write down the time taken for one oscillation when $B = 0.005\,\text{T}$ with its absolute uncertainty. [1]

. . . . . .

(ii) A student forms a hypothesis that the period of one oscillation P is given by:

$$P = \frac{K}{\sqrt{B}}$$

where K is a constant.

Determine the value of K using the point for which $B = 0.005\,\text{T}$.
State the uncertainty in K to an appropriate number of significant figures. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(iii) State the unit of K. [1]

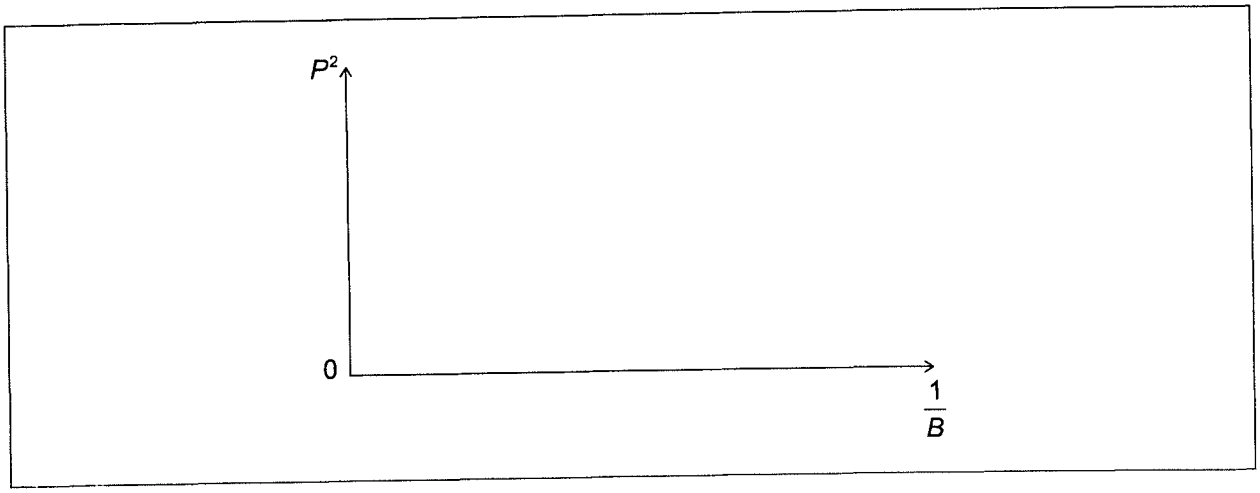
. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) The student plots a graph to show how P^2 varies with $\frac{1}{B}$ for the data.

Sketch the shape of the expected line of best fit on the axes below assuming that the relationship $P = \frac{K}{\sqrt{B}}$ is verified. You do **not** have to put numbers on the axes. [2]

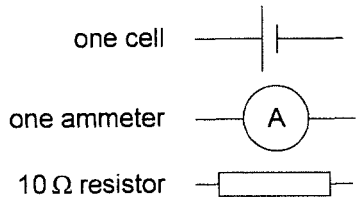


(d) State how the value of K can be obtained from the graph. [1]

.....

.....

2. An experiment to find the internal resistance of a cell of known emf is to be set. The following equipment is available:



(a) Draw a suitable circuit diagram that would enable the internal resistance to be determined. [1]

(b) It is noticed that the resistor gets warmer. Explain how this would affect the calculated value of the internal resistance. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Outline how using a variable resistance could improve the accuracy of the value found for the internal resistance. [2]

. . . . . .

. . . . . .

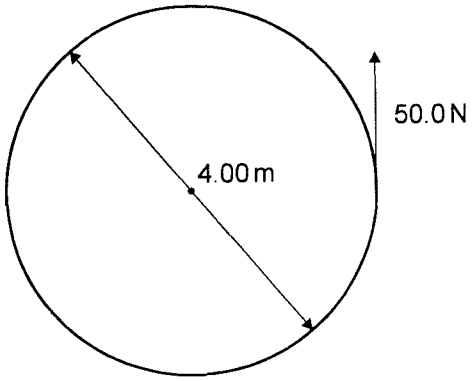
. . . . . .

. . . . . .

. . . . . .

Option B — Engineering physics

6. A constant force of 50.0 N is applied tangentially to the outer edge of a merry-go-round. The following diagram shows the view from above.



The merry-go-round has a moment of inertia of 450 kg m^2 about a vertical axis. The merry-go-round has a diameter of 4.00 m.

(a) Show that the angular acceleration of the merry-go-round is 0.2 rad s^{-2}. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The merry-go-round starts from rest and the force is applied for one complete revolution.

Calculate, for the merry-go-round after one revolution,

(i) the angular speed. [1]

. . . . . .

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B, question 6 continued)

(ii) the angular momentum. [1]

A child of mass 30.0 kg is now placed onto the edge of the merry-go-round. No external torque acts on the system.

(c) Calculate the new angular speed of the rotating system. [2]

(d) The child now moves towards the centre.

(i) Explain why the angular speed will increase. [2]

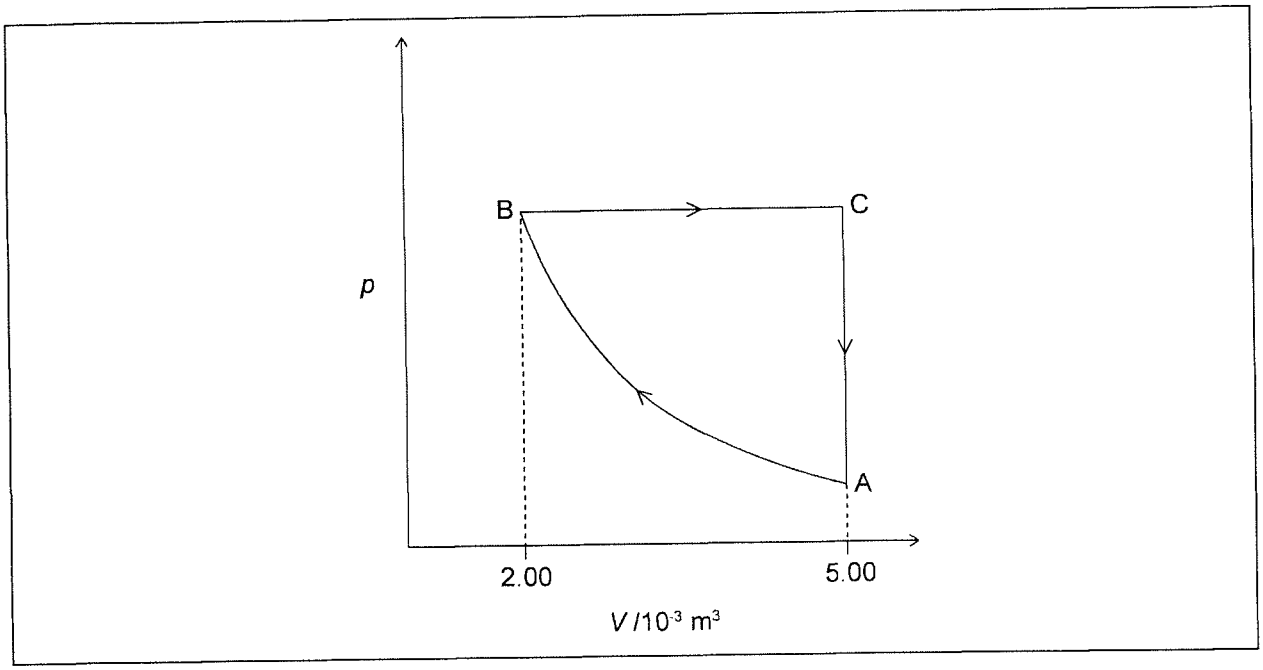
(ii) Calculate the work done by the child in moving from the edge to the centre. [2]

(Option B continues on the following page)

(Option B continued)

7. The pressure–volume (pV) diagram shows a cycle ABCA of a heat engine. The working substance of the engine is 0.221 mol of ideal monatomic gas.

diagram not to scale



At A the temperature of the gas is 295 K and the pressure of the gas is 1.10×10^5 Pa. The process from A to B is adiabatic.

(a) Show that the pressure at B is about 5×10^5 Pa. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) For the process BC, calculate, in J,

(i) the work done by the gas. [1]

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B, question 7 continued)

(ii) the change in the internal energy of the gas. [1]

. . . . . .

. . . . . .

(iii) the thermal energy transferred to the gas. [1]

. . . . . .

. . . . . .

(c) The process from B to C is replaced by an isothermal process in which the initial state is the same and the final volume is $5.00 \times 10^{-3} m^3$.

(i) Explain, without any calculation, why the pressure after this change would be lower if the process was isothermal. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Determine, without any calculation, whether the net work done by the engine during one full cycle would increase or decrease. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Outline why an efficiency calculation is important for an engineer designing a heat engine. [1]

. . . . . .

. . . . . .

End of Option B

More Practice Option B2

This question is about thermodynamics.

(a) The first law of thermodynamics can be written as the following equation.

$$Q = \Delta U + W$$

Identify the symbols in this equation.

Q .....

.....

ΔU .....

.....

W .....

.....

(3)

(b) A fixed mass of an ideal gas is contained in a cylinder by a piston. The friction between the piston and cylinder wall is negligible.

Two procedures are carried out on the gas. The thermal energy input to the gas is the same in both procedures.

Procedure 1 The gas is heated and expands at constant pressure with the piston free to move. The temperature of the gas increases by 21 K.

Procedure 2 The gas is now brought back to its initial state and again heated with the piston fixed in position. The temperature of the gas increases by 35 K.

(i) State the name of the process in procedure 2.

.....

(1)

(ii) Explain why the temperature change is greater in procedure 2 than in procedure 1.

.....

.....

.....

.....

.....

.....

(4)

(iii) In procedure 1, ΔU changes by 120 J. Use the first law of thermodynamics to calculate the missing values in the table below.

	ΔU / J	W / J	Q / J
Procedure 1	+120		+200
Procedure 2			+200

(3)
(Total 11 marks)

MARKSCHEME

(a) *Q:* thermal energy transfer to system;
ΔU: change in/difference in internal energy;
W: work done by system; 3
Accept valid alternative is "transfer from" and "done on".

(b) (i) isochoric / isovolumetric; 1

(ii) in procedure 1 the gas expands against the atmosphere;
this requires extra work to be done;
internal energy change for gas is less;
temperature is a measure of internal energy; 4
Ignore references to return of gas to initial state.

(iii)

	ΔU / J	W / J	Q / J
Procedure 1	*+120*	+80;	*+200*
Procedure 2	+200;	0;	*+200*

3

1. This question is about ideal gases.

(a) The atoms or molecules of an ideal gas are assumed to be identical hard elastic spheres that have negligible volume compared with the volume of the containing vessel.

(i) State **two** further assumptions of the kinetic theory of an ideal gas.

1. .....

.....

2. .....

.....

(2)

(ii) Suggest why only the average kinetic energy of the molecules of an ideal gas is related to the internal energy of the gas.

.....

.....

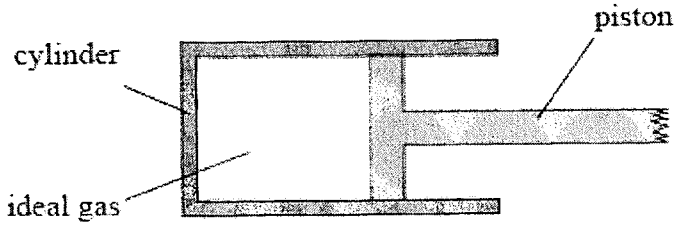
.....

.....

.....

(3)

(b) An ideal gas is contained in a cylinder by means of a frictionless piston.



At temperature 290 K and pressure 4.8×10^5 Pa, the gas has volume 9.2×10^{-4} m^3.

(i) Calculate the number of moles of the gas.

.....

.....

.....

.....

(2)

(ii) The gas is compressed isothermally to a volume of 2.3×10^{-4} m^3. Determine the pressure p of the gas.

.....

.....

.....

(2)

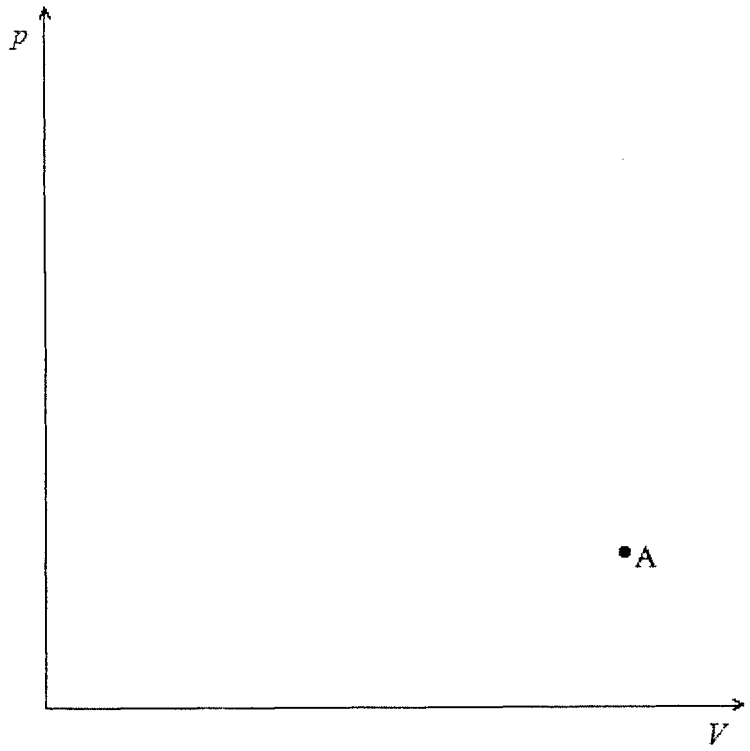
(iii) The gas is now heated at constant volume to a temperature of 420 K. Show that the pressure of the gas is now 2.8×10^6 Pa. (or 2.6×10^6 Pa see note on answer sheet)

.....

.....

(1)

(c) The gas in (b)(iii) is now expanded adiabatically so that its temperature and pressure return to 290 K and 4.8×10^5 Pa respectively. This state is shown below as point A.



(i) Using the axes above sketch a pressure-volume (p-V) diagram for the changes in (b)(ii), (b)(iii) and (c).

(3)

(ii) On your diagram in (c)(i), identify with the letter H any change **or** changes where the gas does external work on its surroundings.

(1)

(iii) Describe how a p-V diagram may be used to estimate a value for the useful work done in one cycle of operation of an engine.

.....

.....

.....

(2)

(Total 16 marks)

(a) (i) random motion;
no gravitational effect;
no forces of attraction between molecules/atoms;
time of collision much less than time between collisions;
Newton's laws apply; 2 max

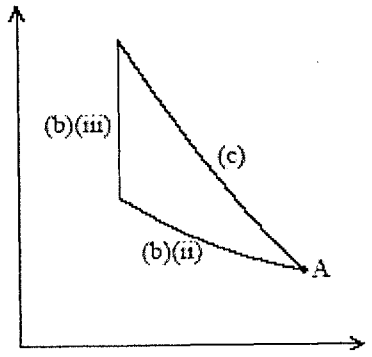
(ii) potential energy not used/irrelevant;
(because) there are no forces between molecules in an ideal gas;
gas speeds vary so need to take an average; 3

(b) (i) $n = \frac{pV}{RT}$;
$n = 0.18$mol; 2
*Award **[2]** for bald correct answer.*

(ii) show use of $pV =$ constant;
19×10^5 Pa; 2
*Award **[2]** for bald correct answer.*

(iii) pressure equals $\frac{420 \times 19 \times 10^5}{290}$;
(to give 2.8×10^6 Pa)
or
pressure $= \left(\frac{nRT}{V} =\right) \frac{0.18 \times 8.31 \times 420}{2.3 \times 10^{-4}}$;

(c) (i)



smooth curve, curving correct way for (b)(ii);
vertical straight line for (b)(iii);
smooth curve, steeper than (b)(ii) for (c); 3
Labelled curves are not needed as such but direction must be clear.

(ii) (c) identified as H; 1

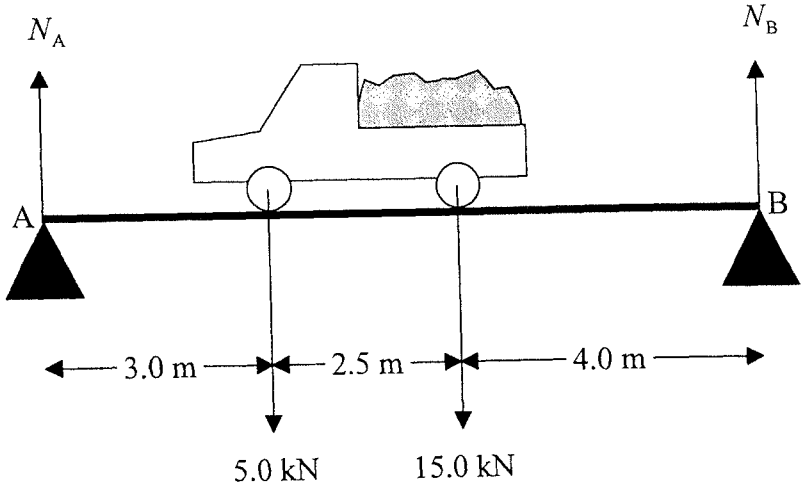
(iii) recognition that area underneath curve is measure of energy;
measure area enclosed by loop / pV changes; 2

[16]

– Mechanics extension

A1. This question is about forces acting on a bridge.

In the diagram below a loaded truck is parked (stationary) on a short bridge that is supported at the points A and B.



The load acting through the front axle is 5.0 kN and the load acting through the rear axle is 15.0 kN.

N_A and N_B are the vertical forces produced on the bridge by the two supports A and B respectively. (The weight of the bridge need not be considered)

(a) Write down the value of $(N_A + N_B)$. *[1]*

.....

(b) Calculate the value of the force N_A and the force N_B when the truck is in the position shown in the diagram. The relevant distances are shown on the diagram and you can assume that the bridge remains rigid. *[3]*

.....

.....

.....

.....

.....