

X069/301

NATIONAL
QUALIFICATIONS
2004

FRIDAY, 28 MAY
1.00 PM – 3.30 PM

PHYSICS
HIGHER

Read Carefully

- 1 All questions should be attempted.

Section A (questions 1 to 20)

- 2 Check that the answer sheet is for Physics Higher (Section A).
- 3 Answer the questions numbered 1 to 20 on the answer sheet provided.
- 4 Fill in the details required on the answer sheet.
- 5 Rough working, if required, should be done only on this question paper, or on the first two pages of the answer book provided—**not** on the answer sheet.
- 6 For each of the questions 1 to 20 there is only **one** correct answer and each is worth 1 mark.
- 7 Instructions as to how to record your answers to questions 1–20 are given on page three.

Section B (questions 21 to 30)

- 8 Answer questions numbered 21 to 30 in the answer book provided.
- 9 Fill in the details on the front of the answer book.
- 10 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 21 to 30.
- 11 Care should be taken to give an appropriate number of significant figures in the final answers to calculations.



DATA SHEET
COMMON PHYSICAL QUANTITIES

<i>Quantity</i>	<i>Symbol</i>	<i>Value</i>	<i>Quantity</i>	<i>Symbol</i>	<i>Value</i>
Speed of light in vacuum	c	$3.00 \times 10^8 \text{ m s}^{-1}$	Mass of electron	m_e	$9.11 \times 10^{-31} \text{ kg}$
Magnitude of the charge on an electron	e	$1.60 \times 10^{-19} \text{ C}$	Mass of neutron	m_n	$1.675 \times 10^{-27} \text{ kg}$
Gravitational acceleration on Earth	g	9.8 m s^{-2}	Mass of proton	m_p	$1.673 \times 10^{-27} \text{ kg}$
Planck's constant	h	$6.63 \times 10^{-34} \text{ J s}$			

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

<i>Substance</i>	<i>Refractive index</i>	<i>Substance</i>	<i>Refractive index</i>
Diamond	2.42	Water	1.33
Crown glass	1.50	Air	1.00

SPECTRAL LINES

<i>Element</i>	<i>Wavelength/nm</i>	<i>Colour</i>	<i>Element</i>	<i>Wavelength/nm</i>	<i>Colour</i>
Hydrogen	656	Red	Cadmium	644	Red
	486	Blue-green		509	Green
	434	Blue-violet		480	Blue
	410	Violet	<i>Lasers</i>		
	397	Ultraviolet	<i>Element</i>	<i>Wavelength/nm</i>	<i>Colour</i>
	389	Ultraviolet	Carbon dioxide	9550 } 10590 }	Infrared
Sodium	589	Yellow	Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

<i>Substance</i>	<i>Density/ kg m⁻³</i>	<i>Melting Point/ K</i>	<i>Boiling Point/ K</i>
Aluminium	2.70×10^3	933	2623
Copper	8.96×10^3	1357	2853
Ice	9.20×10^2	273
Sea Water	1.02×10^3	264	377
Water	1.00×10^3	273	373
Air	1.29
Hydrogen	9.0×10^{-2}	14	20

The gas densities refer to a temperature of 273 K and a pressure of $1.01 \times 10^5 \text{ Pa}$.

SECTION A

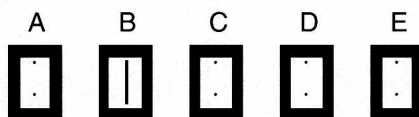
For questions 1 to 20 in this section of the paper, an answer is recorded on the answer sheet by indicating the choice A, B, C, D or E by a stroke made in ink in the appropriate box of the answer sheet—see the example below.

EXAMPLE

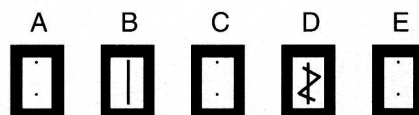
The energy unit measured by the electricity meter in your home is the

- A ampere
- B kilowatt-hour
- C watt
- D coulomb
- E volt.

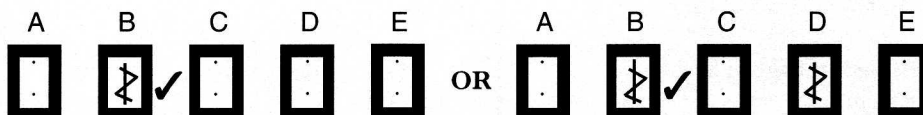
The correct answer to the question is B—kilowatt-hour. Record your answer by drawing a heavy vertical line joining the two dots in the appropriate box on your answer sheet in the column of boxes headed B. The entry on your answer sheet would now look like this:



If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:



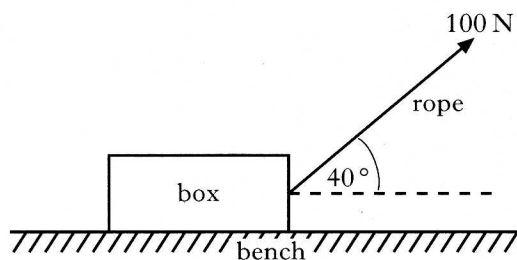
If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the RIGHT of the box of your choice, thus:



SECTION A

Answer questions 1–20 on the answer sheet.

1. A box is pulled along a level bench by a rope held at a constant angle of 40° to the horizontal as shown.

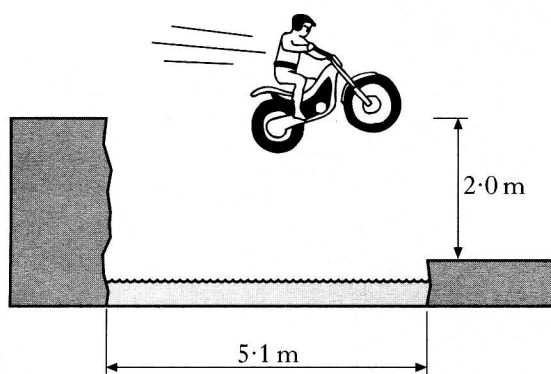


A constant force of 100 N is applied to the rope.

The box moves a distance of 10 m along the bench.

The work done on the box by the rope is

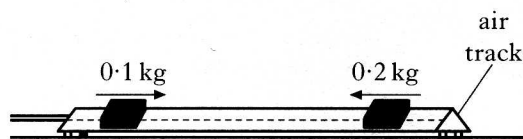
- A 100 J
 - B 643 J
 - C 766 J
 - D 839 J
 - E 1000 J.
2. A stuntman on a motorcycle jumps a river which is 5.1 m wide. He lands on the edge of the far bank, which is 2.0 m lower than the bank from which he takes off.



His minimum horizontal speed at take off is

- A 2.0 m s^{-1}
- B 3.2 m s^{-1}
- C 5.5 m s^{-1}
- D 8.0 m s^{-1}
- E 9.8 m s^{-1} .

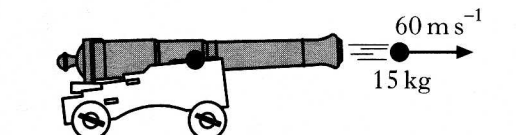
3. A vehicle of mass 0.1 kg is moving to the right along a horizontal friction-free air track. A vehicle of mass 0.2 kg is moving to the left on the same track.



The vehicles collide and stick together.

Which of the following quantities is/are conserved in this collision?

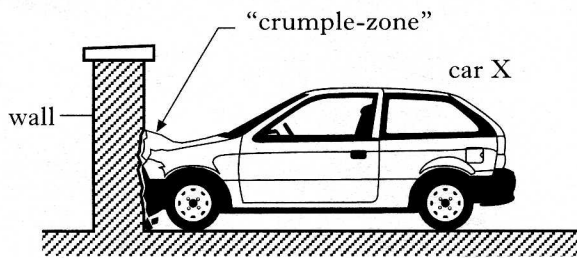
- I The total momentum
 - II The kinetic energy
 - III The total energy
- A I only
 - B II only
 - C I and II only
 - D I and III only
 - E II and III only
4. A cannon of mass 1200 kg fires a cannonball of mass 15 kg at a velocity of 60 m s^{-1} East.



Assuming the force of friction is negligible, the velocity of the cannon just after firing is

- A 0 m s^{-1}
- B 0.75 m s^{-1} East
- C 0.75 m s^{-1} West
- D 6.0 m s^{-1} East
- E 6.0 m s^{-1} West.

5. Car X is designed with a “crumple-zone” so that the front of the car collapses during impact as shown.

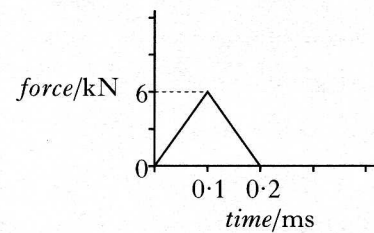


A similar car, Y, of equal mass is built without a crumple-zone. In a safety test both cars are driven at the same speed into identical walls.

Which of the following statements is/are true during the collisions?

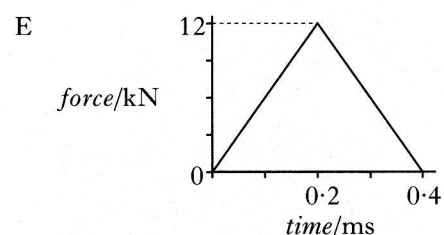
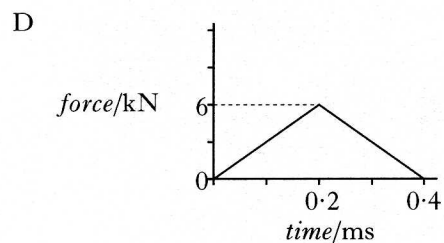
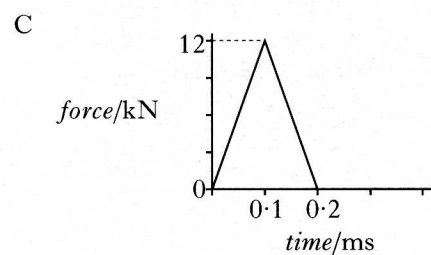
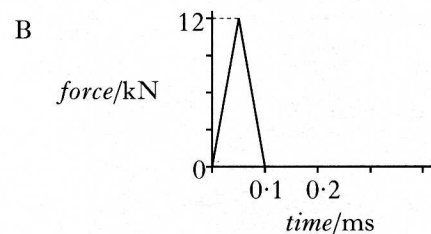
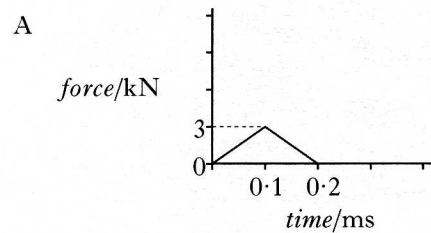
- I The average force on car X is smaller than that on car Y.
 - II The time taken for car X to come to rest is greater than that for car Y.
 - III The change in momentum of car X is smaller than that of car Y.
- A I only
 B I and II only
 C I and III only
 D II and III only
 E I, II and III

6. A golf ball, initially at rest, is hit by a club. The graph of the force of the club on the ball against time is shown.



A different type of golf ball of the same size and mass is now hit with the same club. This ball moves off with the same velocity as the first ball.

Which graph shows the force of the club on the second ball against time?



7. The density of steam at 100°C is less than the density of water at 100°C . The explanation for this is that when water changes to steam its particles

A move further apart
B move with greater speed
C have smaller mass
D are no longer joined together
E collide more often with each other.

8. In an experiment the following measurements and uncertainties are recorded.

Temperature rise = $10^{\circ}\text{C} \pm 1^{\circ}\text{C}$

Heater current = $5.0\text{ A} \pm 0.2\text{ A}$

Heater voltage = $12.0\text{ V} \pm 0.5\text{ V}$

Time = $100\text{ s} \pm 2\text{ s}$

Mass of liquid = $1.000\text{ kg} \pm 0.005\text{ kg}$

The measurement which has the largest percentage uncertainty is the

A temperature rise
B heater current
C heater voltage
D time
E mass of liquid.

9. A balloon of volume of 6.0 m^3 contains a fixed mass of gas at a temperature of 300 K and a pressure of 2.0 kPa . The gas is heated to 600 K and the pressure reduced to 1.0 kPa . The new volume of the gas is

A 1.5 m^3
B 3.0 m^3
C 6.0 m^3
D 12.0 m^3
E 24.0 m^3 .

10. A student writes the following statements about electric fields.

I There is a force on a charge in an electric field.

II When an electric field is applied to a conductor, the free electric charges in the conductor move.

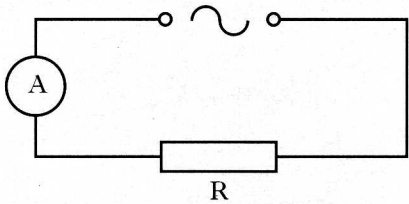
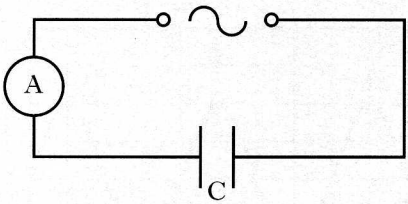
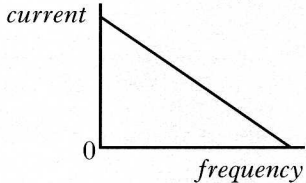
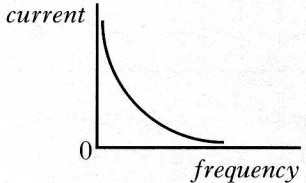
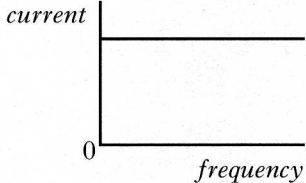
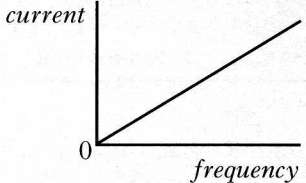
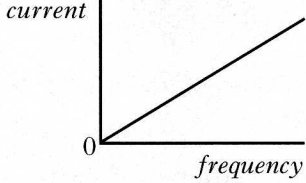
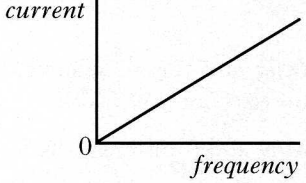
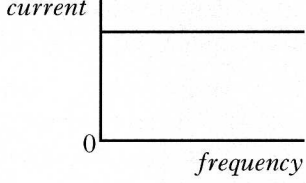
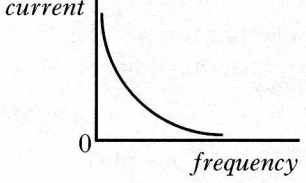
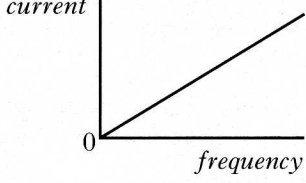
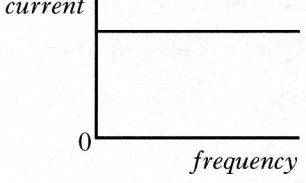
III Work is done when a charge is moved in an electric field.

Which of the above statements is/are correct?

A I only
B II only
C I and II only
D I and III only
E I, II and III

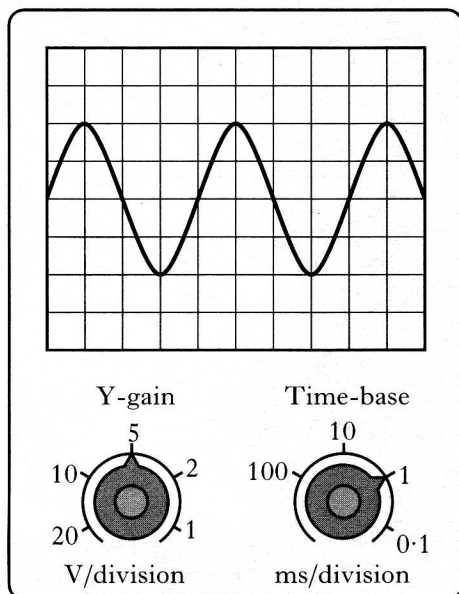
11. A resistor and a capacitor are connected to identical a.c. supplies which provide constant voltage throughout their whole frequency range.

Which of the following pairs of graphs illustrates how the current varies with frequency in the two circuits shown?

	
<p>A</p> 	
<p>B</p> 	
<p>C</p> 	
<p>D</p> 	
<p>E</p> 	

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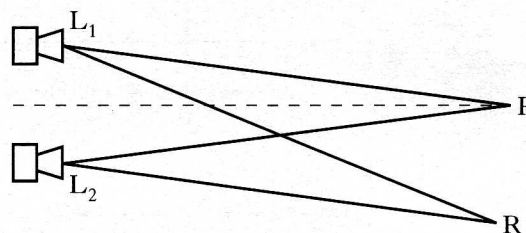
12. The output from a signal generator is connected to the input terminals of an oscilloscope. The trace observed on the oscilloscope screen, the Y-gain setting and the time-base setting are shown in the diagram.



The frequency of the signal shown is calculated using the

- A Y-gain setting and the vertical height of the trace
 B Y-gain setting and the horizontal distance between the peaks of the trace
 C Y-gain setting and time-base setting
 D time-base setting and the vertical height of the trace
 E time-base setting and the horizontal distance between the peaks of the trace.
13. Which of the following statements is/are true for an ideal op-amp?
- I It has infinite input resistance.
 II Both inputs are at the same potential.
 III The input current to the op-amp is zero.
- A I only
 B II only
 C I and II only
 D II and III only
 E I, II and III

14. Two identical loudspeakers, L_1 and L_2 , are operated at the same frequency and in phase with each other. An interference pattern is produced.



At position P, which is the same distance from both loudspeakers, there is a maximum intensity.

The next maximum intensity is at position R, where $L_1R = 5.6$ m and $L_2R = 5.3$ m.

The speed of sound is 340 m s^{-1} .

The frequency of the sound emitted by the loudspeakers is given by

- A $\frac{5.6 - 5.3}{340} \text{ Hz}$
 B $\frac{340}{5.6 + 5.3} \text{ Hz}$
 C $\frac{340}{5.6 - 5.3} \text{ Hz}$
 D $340 \times (5.6 - 5.3) \text{ Hz}$
 E $340 \times (5.6 + 5.3) \text{ Hz}$.

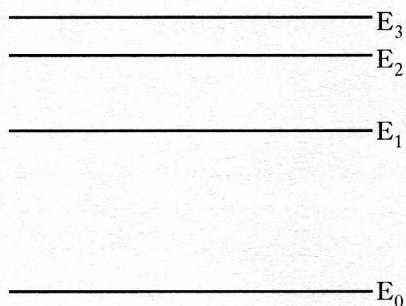
15. Ultraviolet radiation is incident on a clean zinc plate. Photoelectrons are ejected.

The clean zinc plate is replaced by a different metal which has a lower work function. The same intensity of ultraviolet radiation is incident on this metal.

Compared to the zinc plate, which of the following statements is/are true for the new metal?

- I The maximum speed of the photoelectrons is greater.
 II The maximum kinetic energy of the photoelectrons is greater.
 III There are more photoelectrons ejected per second.
- A I only
 B II only
 C III only
 D I and II only
 E I, II and III

16. An atom has the energy levels shown.



Electron transitions occur between all of these levels to produce emission lines in the spectrum of this atom.

How many emission lines are produced by transitions between these energy levels?

- A 3
B 4
C 5
D 6
E 7
17. Materials are “doped” to produce n-type semiconductor material.
- In n-type semiconductor material
- A the majority charge carriers are electrons
B the majority charge carriers are neutrons
C the majority charge carriers are protons
D there are more protons than neutrons
E there are more electrons than neutrons.
18. A student writes the following statements about the decay of radionuclides.

- I During alpha emission a particle consisting of 2 protons and 4 neutrons is emitted from a nucleus.
- II During beta emission a fast moving electron is emitted from a nucleus.
- III During gamma emission a high energy photon is emitted from a nucleus.

Which of these statements is/are true?

- A II only
B I and II only
C I and III only
D II and III only
E I, II and III

19. A radiation technician works 150 hours each month in an area exposed to radiation from a neutron beam. The quality factor for this radiation is 3. The technician receives an absorbed dose rate of $10\mu\text{Gy h}^{-1}$ from this radiation.

In a period of 5 months the total dose equivalent received by the technician is

- A $2.50 \times 10^{-2} \text{ Sv}$
B $2.25 \times 10^{-2} \text{ Sv}$
C $1.50 \times 10^{-2} \text{ Sv}$
D $1.00 \times 10^{-2} \text{ Sv}$
E $0.75 \times 10^{-2} \text{ Sv}$.

20. A Geiger counter records a corrected count-rate of 1000 counts per second when it is placed a distance of 400 mm from a radioactive source.

A sheet of metal is placed between the source and the counter. The half value thickness of the metal for radiation from the source is 20 mm.

The corrected count-rate is now 125 counts per second.

The thickness of the metal sheet is

- A 25 mm
B 40 mm
C 60 mm
D 80 mm
E 160 mm.

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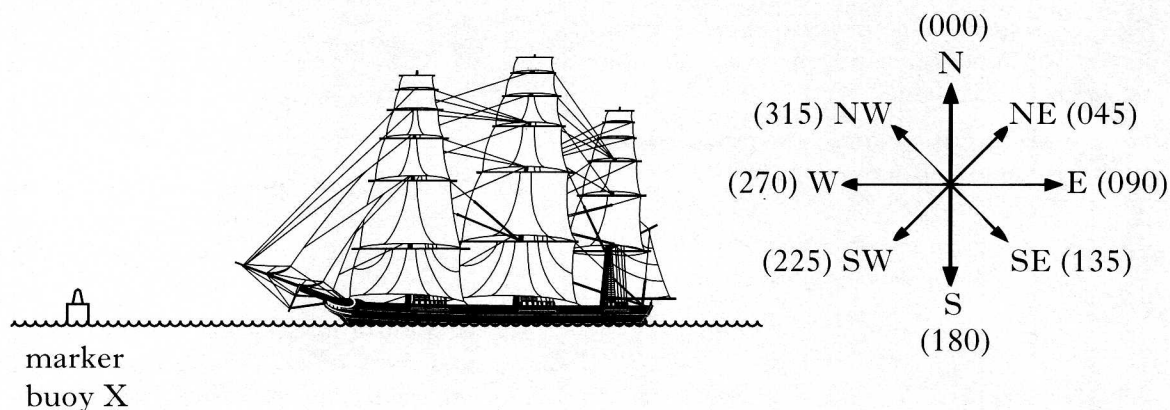
SECTION B

Write your answers to questions 21 to 30 in the answer book.

Marks

21. (a) State the difference between speed and velocity. 1

(b) During a tall ships race, a ship called the Mir passes a marker buoy X and sails due West (270). It sails on this course for 30 minutes at a speed of 10.0 km h^{-1} , then changes course to 20° West of North (340). The Mir continues on this new course for $1\frac{1}{2}$ hours at a speed of 8.0 km h^{-1} until it passes marker buoy Y.



(i) Show that the Mir travels a total distance of 17 km between marker buoys X and Y.

(ii) By scale drawing or otherwise, find the displacement from marker buoy X to marker buoy Y.

(iii) Calculate the average velocity, in km h^{-1} , of the Mir between marker buoys X and Y. 6

(c) A second ship, the Leeuvin, passes marker buoy X 15 minutes after the Mir and sails directly for marker buoy Y at a speed of 7.5 km h^{-1} .

Show by calculation which ship first passes marker buoy Y. 2

(9)

