

# X069/301

NATIONAL  
QUALIFICATIONS  
2005

TUESDAY, 24 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 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.  
Do not change any of these details.
- 4 If any of this information is wrong, tell the Invigilator immediately.
- 5 If this information is correct, **print** your name and seat number in the boxes provided.
- 6 Use **black** or **blue ink** for your answers. **Do not use red ink.**
- 7 There is **only one correct** answer to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the exam, put the **answer sheet for Section A inside the front cover of your answer book.**
- 10 Instructions as to how to record your answers to questions 1–20 are given on page three.

## Section B (questions 21 to 30)

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



**DATA SHEET**  
COMMON PHYSICAL QUANTITIES

Quantity	Symbol	Value	Quantity	Symbol	Value
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	$g$	$9.8 \text{ m s}^{-2}$	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.

Substance	Refractive index	Substance	Refractive index
Diamond	2.42	Water	1.33
Crown glass	1.50	Air	1.00

**SPECTRAL LINES**

Element	Wavelength/nm	Colour	Element	Wavelength/nm	Colour
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**

Substance	Density/ $\text{kg m}^{-3}$	Melting Point/ K	Boiling Point/ K
Aluminium	$2.70 \times 10^3$	933	2623
Copper	$8.96 \times 10^3$	1357	2853
Ice	$9.20 \times 10^2$	273	....
Sea Water	$1.02 \times 10^3$	264	377
Water	$1.00 \times 10^3$	273	373
Air	1.29	....	....
Hydrogen	$9.0 \times 10^{-2}$	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 the answer to each question is either A, B, C, D or E. Decide what your answer is, then put a horizontal line in the space provided—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 is **B**—kilowatt-hour. The answer **B** has been clearly marked with a horizontal line (see below).

A	B	C	D	E
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **B**.

A	B	C	D	E
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:

A	B	C	D	E
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

 or 

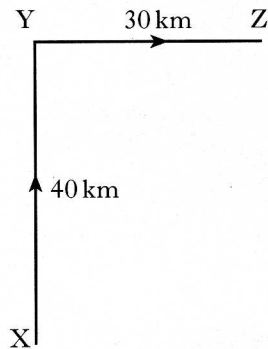
A	B	C	D	E
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

[Turn over

SECTION A

Answer questions 1–20 on the answer sheet.

1. A car travels from X to Y and then from Y to Z as shown.



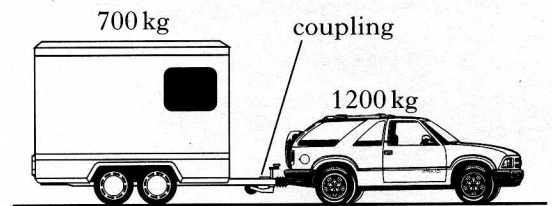
It takes one hour to travel from X to Y. It also takes one hour to travel from Y to Z.

Which row in the following table shows the magnitudes of the displacement, average speed and average velocity for the complete journey?

	<i>Displacement</i> (km)	<i>Average speed</i> (km h <sup>-1</sup> )	<i>Average velocity</i> (km h <sup>-1</sup> )
A	50	35	25
B	70	35	25
C	50	35	35
D	70	70	50
E	50	70	25

2. An object has a constant acceleration of  $3 \text{ m s}^{-2}$ . This means that the
- A distance travelled by the object increases by 3 metres every second
  - B displacement of the object increases by 3 metres every second
  - C speed of the object is  $3 \text{ m s}^{-1}$  every second
  - D velocity of the object is  $3 \text{ m s}^{-1}$  every second
  - E velocity of the object increases by  $3 \text{ m s}^{-1}$  every second.

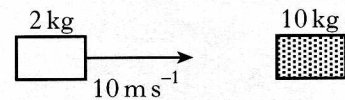
3. A car of mass 1200 kg pulls a horsebox of mass 700 kg along a straight, horizontal road. They have an acceleration of  $2.0 \text{ m s}^{-2}$ .



Assuming that the frictional forces are negligible, the tension in the coupling between the car and the horsebox is

- A 500 N
  - B 700 N
  - C 1400 N
  - D 2400 N
  - E 3800 N.
4. A mass of 2 kg slides along a frictionless surface at  $10 \text{ m s}^{-1}$  and collides with a stationary mass of 10 kg.

**before impact**



After the collision, the 2 kg mass rebounds at  $5 \text{ m s}^{-1}$  and the 10 kg mass moves off at  $3 \text{ m s}^{-1}$ .

**after impact**



Which row in the following table is correct?

	<i>Momentum of system</i>	<i>Kinetic energy of system</i>	<i>Type of collision</i>
A	conserved	conserved	elastic
B	conserved	not conserved	inelastic
C	conserved	not conserved	elastic
D	not conserved	not conserved	inelastic
E	not conserved	not conserved	elastic

5. A golfer hits a ball of mass  $5.0 \times 10^{-2}$  kg with a golf club. The ball leaves the tee with a velocity of  $80 \text{ ms}^{-1}$ . The club is in contact with the ball for a time of 0.10 s.

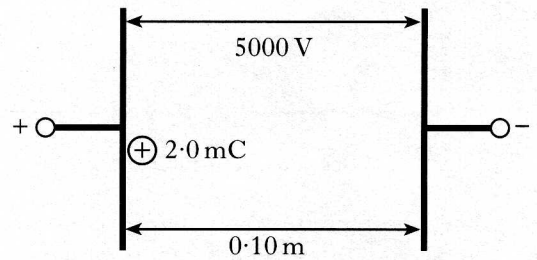
The average force exerted by the club on the ball is

- A  $6.25 \times 10^{-4}$  N  
 B 0.025 N  
 C 0.4 N  
 D 4 N  
 E 40 N.
6. A solid at a temperature of  $-20^\circ\text{C}$  is heated until it becomes a liquid at  $70^\circ\text{C}$ .  
 The temperature change in kelvin is
- A 50 K  
 B 90 K  
 C 343 K  
 D 363 K  
 E 596 K.

7. One volt is

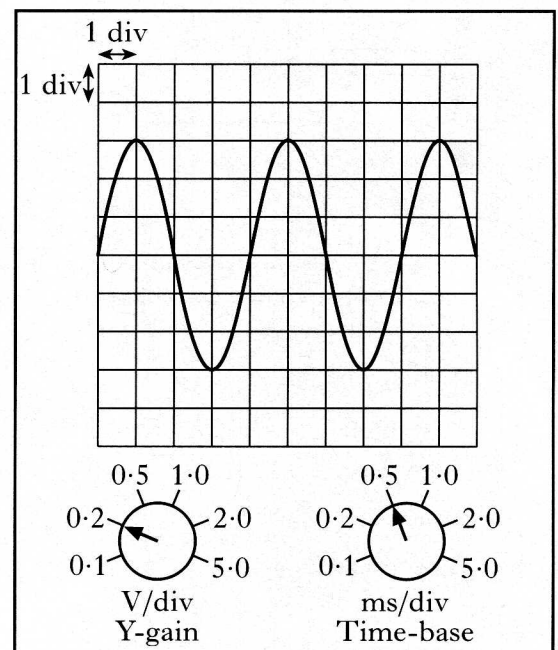
- A one coulomb per joule  
 B one joule coulomb  
 C one joule per coulomb  
 D one joule per second  
 E one coulomb per second.

8. A potential difference of 5000 V is applied between two metal plates. The plates are 0.10 m apart. A charge of  $+2.0 \text{ mC}$  is released from rest at the positively charged plate as shown.



The kinetic energy of the charge just before it hits the negative plate is

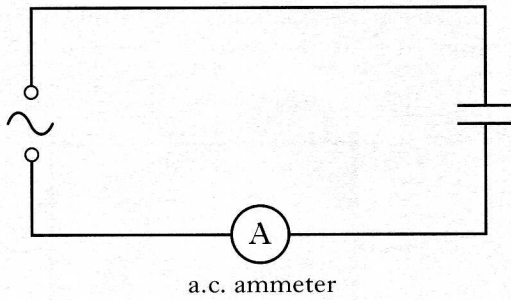
- A  $4.0 \times 10^{-7}$  J  
 B  $2.0 \times 10^{-4}$  J  
 C 5.0 J  
 D 10 J  
 E 500 J.
9. An a.c. signal is displayed on an oscilloscope screen. The Y-gain and time-base controls are set as shown.



The frequency of the signal is

- A 0.50 Hz  
 B 1.25 Hz  
 C 2.00 Hz  
 D 200 Hz  
 E 500 Hz.

10. A capacitor is connected to a circuit as shown.

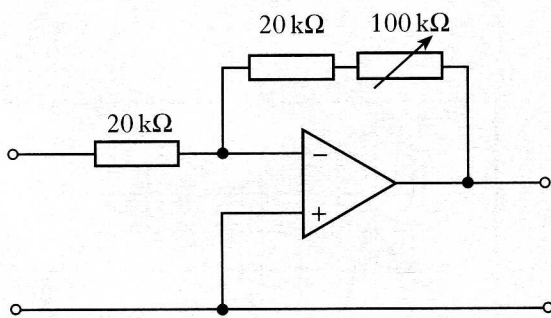


The alternating supply has a constant peak voltage but its frequency can be varied.

The frequency is steadily increased from 50 Hz to 5000 Hz. The reading on the a.c. ammeter

- A remains constant
- B decreases steadily
- C increases steadily
- D increases then decreases
- E decreases then increases.

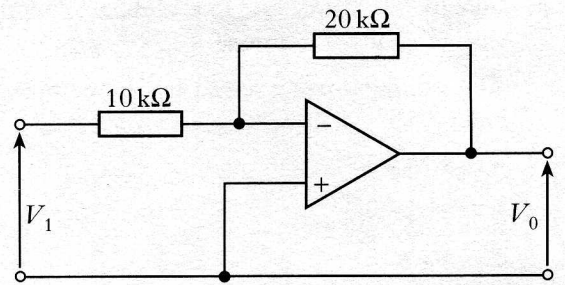
11. An amplifier circuit is shown.



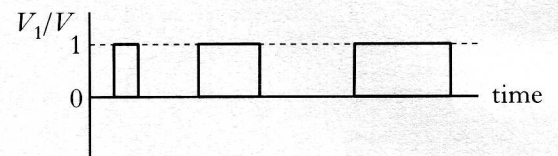
The variable resistor can be adjusted from zero to 100 kΩ. This allows the voltage gain to be altered over the range

- A zero to one
- B zero to five
- C zero to six
- D one to five
- E one to six.

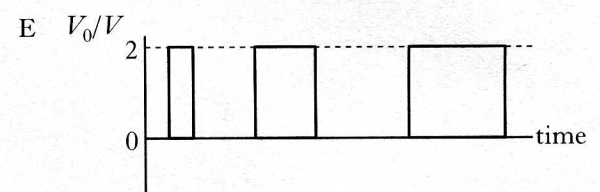
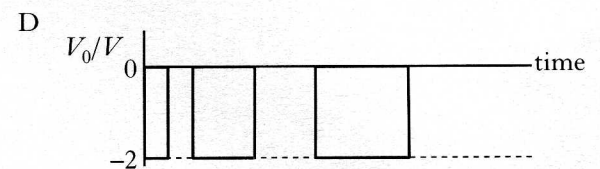
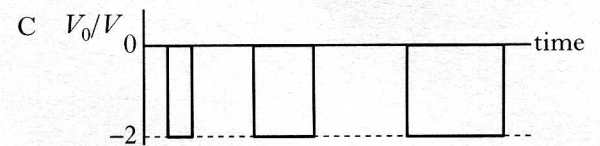
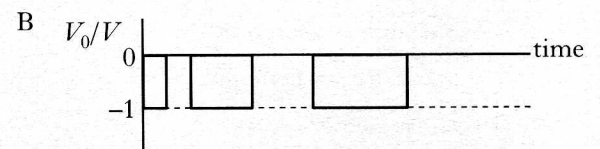
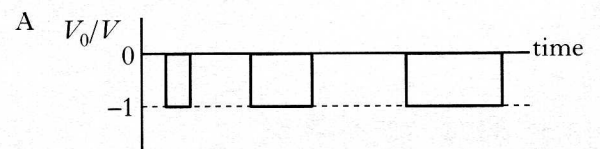
12. A student sets up the following circuit.



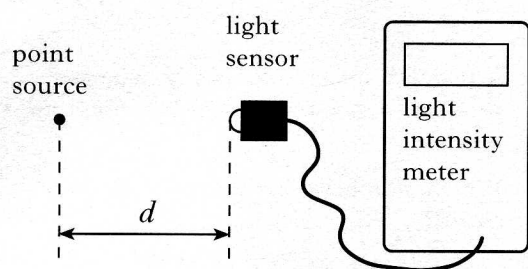
The graph below shows how the input voltage  $V_1$  varies with time.



Which of the following graphs shows how the output voltage  $V_0$  varies with time?



13. The apparatus used to investigate the relationship between light intensity  $I$  and distance  $d$  from a point source is shown.



The experiment is carried out in a darkened room.

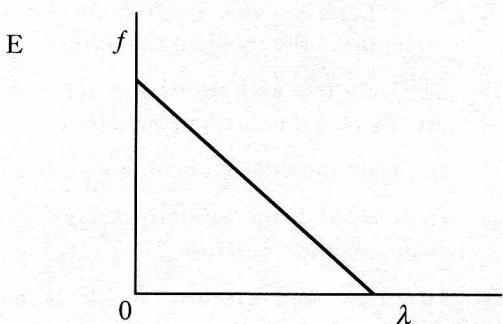
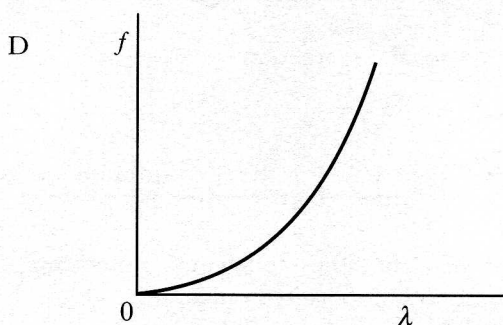
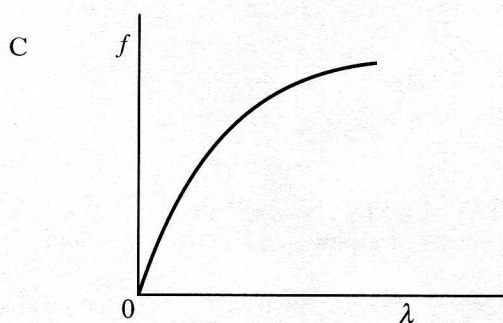
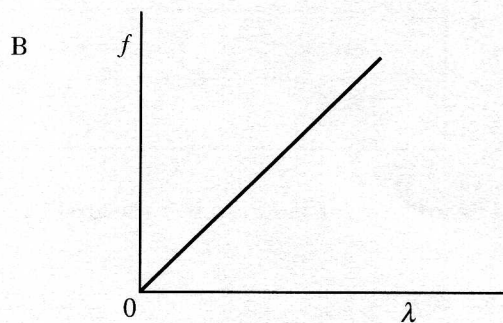
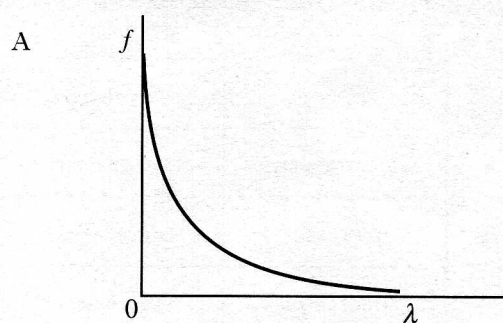
Which of the following expressions gives a constant value?

- A  $I \times d$   
 B  $I \times d^2$   
 C  $\frac{I}{d}$   
 D  $\frac{I}{d^2}$   
 E  $I \times \sqrt{d}$
14. Microwaves of frequency  $2.0 \times 10^{10}$  Hz travel through air with a speed of  $3.0 \times 10^8$  ms<sup>-1</sup>. On entering a bath of oil, the speed reduces to  $1.5 \times 10^8$  ms<sup>-1</sup>.

The frequency of the microwaves in the oil is

- A  $1.0 \times 10^{10}$  Hz  
 B  $2.0 \times 10^{10}$  Hz  
 C  $4.0 \times 10^{10}$  Hz  
 D  $3.0 \times 10^{18}$  Hz  
 E  $6.0 \times 10^{18}$  Hz.

15. Which graph shows the relationship between frequency  $f$  and wavelength  $\lambda$  of photons of electromagnetic radiation?



16. A liquid and a solid have the same refractive index.

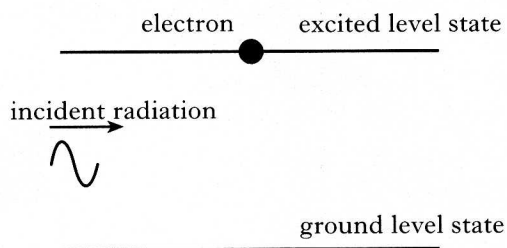
What happens to the speed and the wavelength of light passing from the liquid into the solid?

	<i>Speed</i>	<i>Wavelength</i>
A	stays the same	stays the same
B	decreases	decreases
C	decreases	increases
D	increases	increases
E	increases	decreases

17. The intensity of light can be measured in

- A W  
 B  $\text{W m}^{-1}$   
 C W m  
 D  $\text{W m}^{-2}$   
 E  $\text{W m}^2$ .

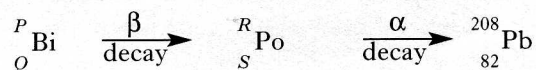
18. The diagram below represents part of the process of stimulated emission in a laser.



Which of the following statements best describes the emitted radiation?

- A Out of phase and emitted in the same direction as the incident radiation  
 B Out of phase and emitted in the opposite direction to the incident radiation  
 C In phase and emitted in all directions.  
 D In phase and emitted in the same direction as the incident radiation  
 E In phase and emitted in the opposite direction to the incident radiation

19. Part of a radioactive decay series is shown.

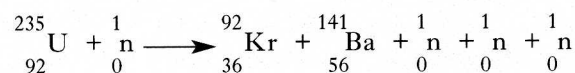


A bismuth nucleus emits a beta particle and its product, a polonium nucleus, emits an alpha particle.

Which numbers are represented by *P*, *Q*, *R* and *S*?

	<i>P</i>	<i>Q</i>	<i>R</i>	<i>S</i>
A	212	85	212	84
B	212	83	212	84
C	212	85	208	83
D	210	83	208	81
E	210	85	210	84

20. The equation below represents a nuclear reaction.



It is an example of

- A nuclear fusion  
 B alpha particle emission  
 C beta particle emission  
 D induced nuclear fission  
 E spontaneous nuclear fission.

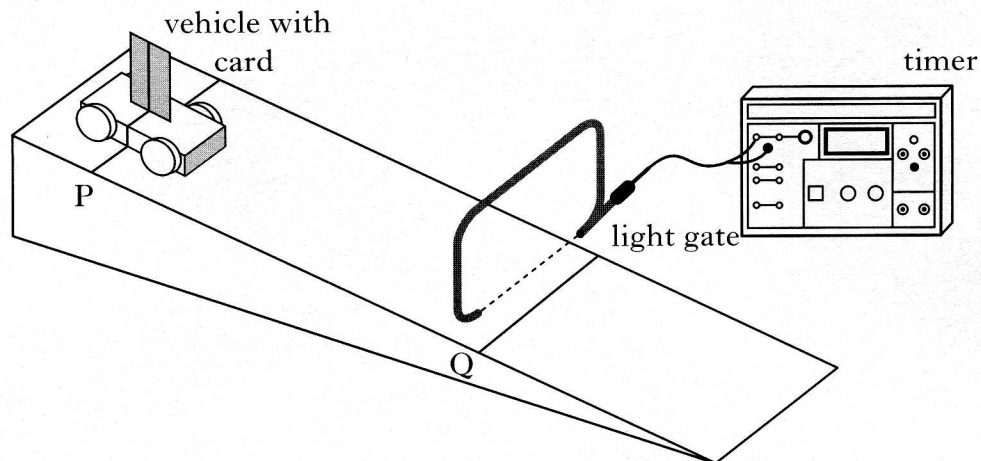
**[SECTION B begins on *Page ten*]**

**[Turn over**

## SECTION B

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

21. (a) A student uses the apparatus shown to measure the average acceleration of a trolley travelling down a track.



The line on the trolley is aligned with line P on the track.

The trolley is released from rest and allowed to run down the track.

The timer measures the time for the card to pass through the light gate.

This procedure is repeated a number of times and the results shown below.

0.015 s    0.013 s    0.014 s    0.019 s    0.017 s    0.018 s

- (i) Calculate:

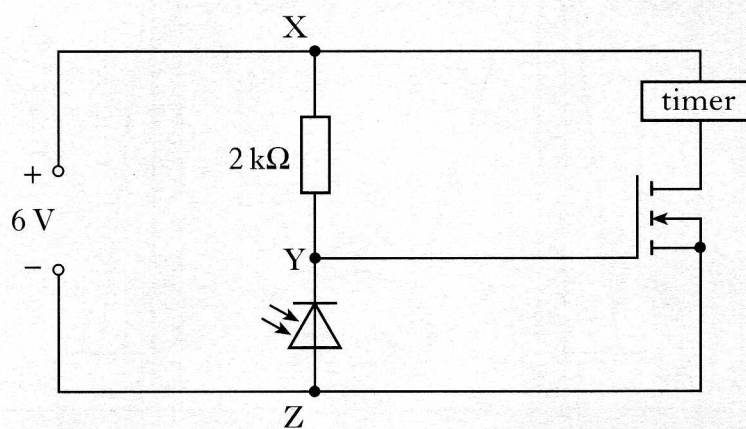
- (A) the mean time for the card to pass through the light gate; 1  
 (B) the approximate absolute random uncertainty in this value. 1

- (ii) The length of the card is 0.020 m and the distance PQ is 0.60 m.

Calculate the acceleration of the trolley (an uncertainty in this value is not required). 3

## 21. (continued)

- (b) The light gate consists of a lamp shining onto a photodiode.  
The photodiode forms part of the circuit shown.



- (i) In which mode is the photodiode operating? 1
- (ii) Explain why the timer only operates while the light beam is broken. 2
- (8)**

**[Turn over**

