# Test 5

**Core short answer questions: 60 marks**
**Suggested time: 70–80 minutes**

## Core short answer questions

**Specific instructions to students**

- Answer **all** questions in the spaces provided.
- For all questions which require a numerical answer you must show all working.
- You should take the value of $g$ to be 10 $ms^{-2}$.

A group of students are standing on a bridge, trying to see who can throw a stone the farthest from the bridge, into the river below. Where the students are throwing their stones from is 6.5 m above the water. One of the students measures the time it takes for a stone thrown by someone else to return to the launch height to be 3.6 s.

**QUESTION 1** **2 marks**

What is the initial vertical component of the stone's velocity?

taking up as positive vertically to the top:
$u = ?$, $v = 0$, $a = -10$,
$t = 3.60 \div 2 = 1.80$
$v = u + at$
$0 = u + -10 \times 1.8$
$u = 18$ $ms^{-1}$

**Answer:**

18 $ms^{-1}$

**QUESTION 2** **3 marks**

What vertical height does the stone reach above the water?

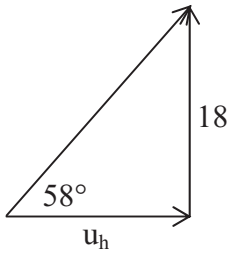
taking up as positive vertically to the top:
$v = 0$, $a = -10$, $t = 1.8$, $s = ?$
$s = vt - \frac{1}{2} at^2$
$= 0 - \frac{1}{2} \times -10 \times 1.8^2$
$s = 16.2$
height = 16.2 + 6.5 = 22.7 m

**Answer:**

22.7 m

**QUESTION 3** **3 marks**

What is the initial horizontal component of the stone's velocity if it leaves the thrower's hand at an angle of 58° to the horizontal?




vertically: $u = 18$ $ms^{-1}$
$\tan 58° = 18 \div u_h$
$u_h = 18 \div \tan 58°$
$= 11.248$ $ms^{-1}$

**Answer:**

11.2 $ms^{-1}$

**QUESTION 4** **4 marks**

What horizontal distance from the bridge does the stone travel before it hits the water?

vertically:
$u = 18$, $a = -10$,
$s = -6.5$, $t = ?$
$s = ut + \frac{1}{2} at^2$
$-6.5 = 18t - 5t^2$
$5t^2 - 18t - 6.5 = 0$
solving gives $t = 3.93$ s
horizontally:
$u = 11.2$, $v = 11.2$,
$a = 0$, $t = 3.93$, $s = ?$
$s = ut + \frac{1}{2} at^2$
$= 11.2 \times 3.93$
$= 44$ m

**Answer:**

44 m

A 540 g metal ball is rolling along a flat, frictionless surface at a speed of 2.3 $ms^{-1}$ as shown in the diagram.


**QUESTION 5** **2 marks**

How much kinetic energy does the metal ball possess?

$KE = \frac{1}{2} mv^2$
$= \frac{1}{2} \times 540 \times 10^{-3} \times 2.3^2$
$= 1.43$ J or 1.4 J

**Answer:**

1.4 J

The ball encounters a slope inclined at 32° to the horizontal.

**QUESTION 6** **2 marks**

What vertical height '*h*' will the ball reach up the slope before it stops and rolls back down?

KE is converted to GPE
$1.4 = mgh$
$1.4 = 540 \times 10^{-3} \times 10 \times h$
$h = 0.259$ m
0.26 m

**Answer:**

0.26 m

The mass of the Moon is $7.35 \times 10^{22}$ kg and the mass of the Earth is $5.98 \times 10^{24}$ kg. The radius of the Moon's orbit around the Earth is $3.84 \times 10^{8}$ m.

**QUESTION 7** **2 marks**

Calculate the magnitude of the gravitational force between the Moon and the Earth.

$F = G m_{Moon} m_{Earth}/r^2$
$= (6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 5.98 \times 10^{24})$
$\div (3.84 \times 10^{8})^2$
$= 1.99 \times 10^{20}$ N

**Answer:**

$1.99 \times 10^{20}$ N

**QUESTION 8** **2 marks**

Calculate the magnitude of the Earth's gravitational field at the position of the Moon.

$g = G m_{Earth}/r^2$
$= (6.67 \times 10^{-11} \times 5.98 \times 10^{24}) \div (3.84 \times 10^{8})^2$
$= 2.70 \times 10^{-3}$ Nkg$^{-1}$

**Answer:**

$2.70 \times 10^{-3}$ Nkg$^{-1}$

**QUESTION 9** **2 marks**

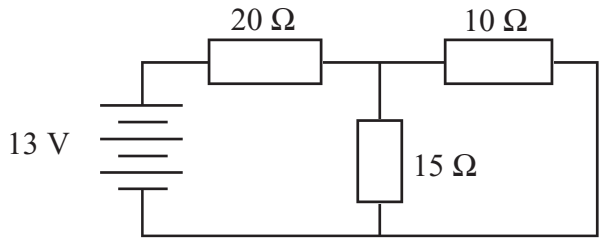
Calculate the magnitude of the Moon's gravitational field at the position of the Earth.

$g = G m_{Moon}/r^2$
$= (6.67 \times 10^{-11} \times 7.35 \times 10^{22}) \div (3.84 \times 10^{8})^2$
$= 3.32 \times 10^{-5}$ Nkg$^{-1}$

**Answer:**

$3.32 \times 10^{-5}$ Nkg$^{-1}$

Three resistors are connected in a circuit as shown below.




**QUESTION 10** **2 marks**

Calculate the effective resistance of this circuit.

$R_{parallel} = (10^{-1} + 15^{-1})^{-1}$
$= 6$
$R_{effective} = 6 + 20$
$= 26\ \Omega$

**Answer:**

26 Ω

**QUESTION 11** **2 marks**

Calculate the current flowing through the 20 Ω resistor.

$I = V \div R$
$= 13 \div 26$
$= 0.5$ A

**Answer:**

0.5 A

**QUESTION 12** **3 marks**

Calculate the power output of the 10 Ω resistor.

$V_{20} = IR$

$= 0.5 \times 20 = 10$ V

$V_{\text{parallel combination}} = 13 - 10 = 3$ V

$P_{10} = V^2 \div R$

$= 3^2 \div 10$

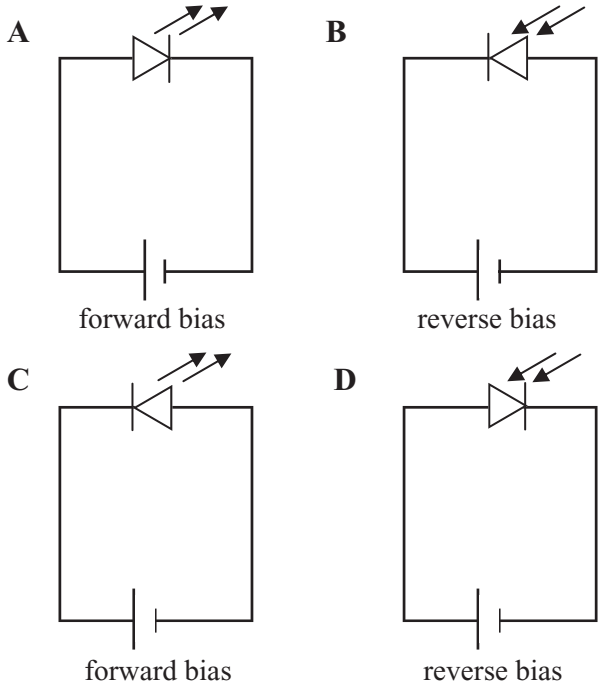
$= 0.9$ W

**Answer:**

0.9 W

**QUESTION 13** **2 marks**

Which of the following circuit diagrams and bias description is correct for an LED?




**Answer:**

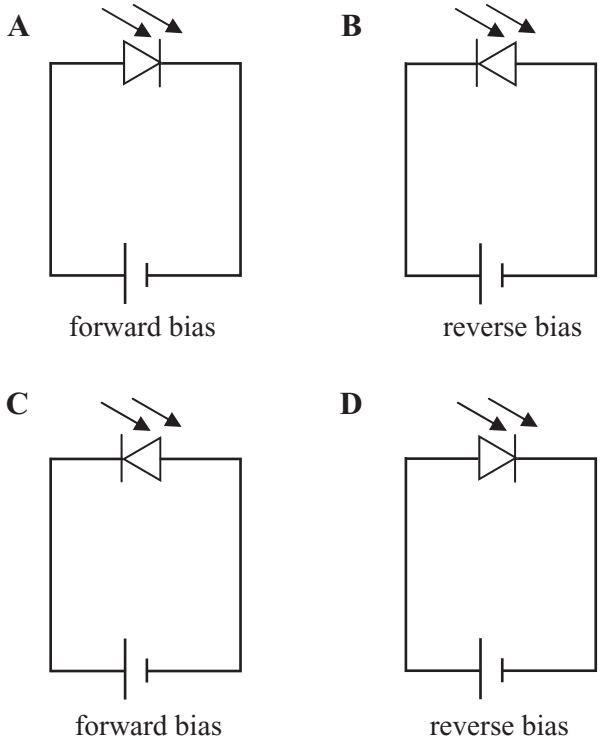
A

LEDs operate in forward bias and emit light,

∴ the arrows point away from the circuit symbol.

**QUESTION 14** **2 marks**

Which of the following circuit diagrams and bias descriptions is correct for a photodiode operating correctly?




**Answer:**

B

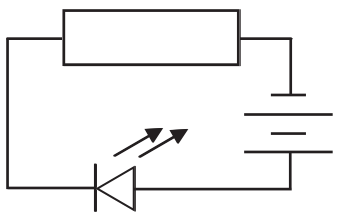
A photodiode operates correctly when reverse biased

so the symbol 'points' to the left.

An LED is normally connected in a circuit with a limiting resistor and power supply.

**QUESTION 15** **2 marks**

Complete the circuit diagram below to show how such a circuit would be connected.



or similar

**QUESTION 16** **2 marks**

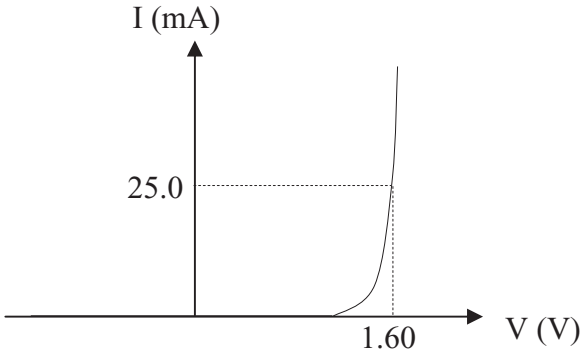
Why is a limiting resistor used in LED circuits?

**Answer:**

The limiting resistor reduces the potential difference across the LED to the required value and therefore prevents the LED from being damaged.

**QUESTION 17** **2 marks**

If the graph below represents an I−V characteristic for a typical LED circuit powered by a potential difference of 6 V, what value limiting resistor would be needed?




$V_R = 6.00 - 1.60$
$= 4.40$ V
$R = V \div I$
$= 4.40 \div (25.0 \times 10^{-3})$
$= 176\ \Omega$

**Answer:**

176 Ω

In many applications, LEDs are preferable to ordinary light globes.

**QUESTION 18** **2 marks**

What are two advantages of LEDs over ordinary light globes?

**Answer:**

Any two of the following:

- LEDs are very durable
- LEDs emit light using very low voltages
- LEDs will operate for extended periods of time – up to 500 times longer than ordinary light globes
- LEDs consume much less power than ordinary light globes

An 80 Ω resistor is connected in series with a different LED and a 12 V power supply.

**QUESTION 19** **3 marks**

Calculate the current in mA flowing through the LED if it has a potential difference of 1.8 V across it. Give your answer in mA.

$V_R = 12 - 1.8$
$= 10.2$ V
$I = V \div R = 10.2 \div 80$
$= 0.1275$ A $= 128$ mA

**Answer:**

128 mA

**QUESTION 20** **3 marks**

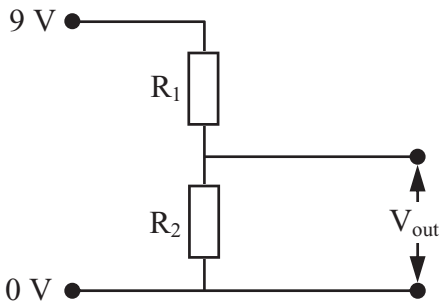
This circuit is not ideal to operate the LED. Explain your answer and suggest an alternative arrangement if necessary.

**Answer:**

The current is quite high and may damage the LED. A larger resistor would reduce the current to a more suitable level.

**QUESTION 21** **2 marks**

For the voltage divider circuit shown below, what is the output voltage if $R_1 = 3$ kΩ and $R_2 = 6$ kΩ?




$V_{out} = R_2/(R_1 + R_2)V_{in}$
$= 6 \div (3 + 6) \times 9$

**Answer:**

6 V

**QUESTION 22** **3 marks**

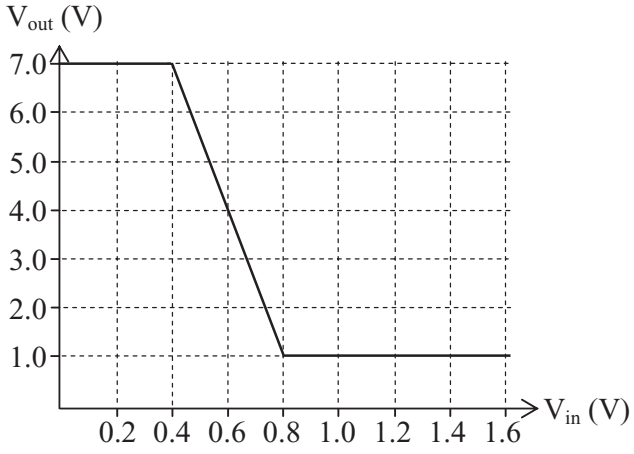
If $R_2 = 5$ kΩ, what value of $R_1$ will produce an output voltage of 0.6 V? Give your answer in kΩ.

Rearranging the voltage divider formula gives:
$R_1 = R_2 (V_{in} - V_{out})/V_{out}$
$= 5 \times (9 - 0.6) \div 0.6$

**Answer:**

70 kΩ

The diagram below represents the transfer characteristic for a voltage amplifier.




**QUESTION 23** **2 marks**

State the input voltage that provides the ideal operating condition for this amplifier and the corresponding output voltage.

**Answer:**

| input bias voltage = 0.6 V |
|---|
| output voltage = 4 V |

The ideal operating condition is the centre of the sloping section of the transfer characteristic.

**QUESTION 24** **2 marks**

Calculate the voltage gain of this amplifier.

gain = $\Delta V_{out} \div \Delta V_{in}$
= 6 ÷ 0.4
= 15

**Answer:**

15

**QUESTION 25** **1 mark**

What is the value of $V_{out}$ when $V_{in}$ = 0.7 V?

**Answer:**

2.5 V

**QUESTION 26** **1 mark**

What is the value of $V_{out}$ when $V_{in}$ = 0.5 V?

**Answer:**

5.5 V

**QUESTION 27** **2 marks**

On the axes below, draw the output voltage for the following input voltage. Include values on the $V_{out}$ axis.