## 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$^{-2}$.

Two teenage boys, John and Damien, who also happen to be Physics students, are attempting to push a large box of mass 60 kg along a carpeted floor. When the boys apply a horizontal force of 100 N, the box fails to move.


Damien explains the fact that the box doesn't move by using Newton's first law.

**QUESTION 1** **4 marks**

Is Newton's first law appropriate to this situation and how is Damien likely to correctly phrase his explanation?

**Answer:**

Newton's first law is applicable in this situation. Damien is most likely to state that the box remains at rest because although it has a 100 N force applied to it another 100 N force, the force of friction, opposes the box's motion. This produces a zero net force on the box. According to Newton's first law, since there is no net force acting on the box there will be no change in the box's stationary motion.

On a smooth floor surface, the box moves forwards with an acceleration of 1 ms$^{-2}$ under the action of a similar 100 N force.

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

What is the size of the force of friction acting on the box in this situation?

$$F_{net} = F_{applied} - F_{opposing}$$
$$60 \times 1 = 100 - F_{opposing}$$
$$F_{opposing} = 100 - 60$$
$$= 40 \text{ N}$$

**Answer:**

40 N

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

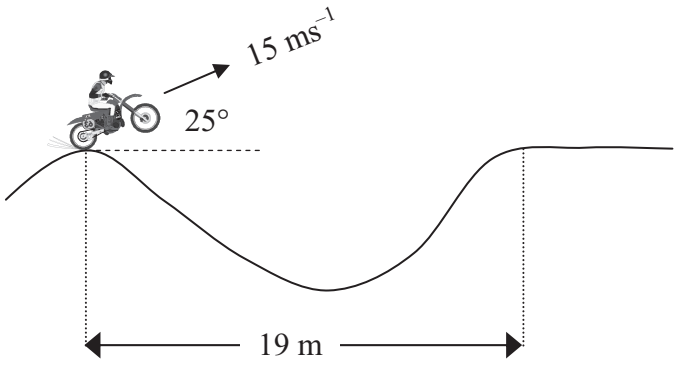
What would be the magnitude of the box's deceleration at the instant when the 100 N force is removed?

$$F_{net} = F_{applied} - F_{opposing}$$
$$60 \times a = 0 - 40$$
$$a = -40 \div 60$$
magnitude of $a$ = 0.67 or 0.7 ms$^{-2}$

**Answer:**

0.7 ms$^{-2}$

While riding his motorbike on a dirt track, a motorbike rider travels over a bump on the track at high speed and launches himself and his motorbike into the air. The launch speed is 15 ms$^{-1}$ at an angle of 25° to the horizontal.




**QUESTION 4** **2 marks**

Calculate the vertical and horizontal components of the bike's launch speed.

vertical component
= 15 sin25°
= 6.339
= 6.3 ms$^{-1}$
horizontal component
= 15 cos25°
= 13.595
= 13.6 or 14 ms$^{-1}$

**Answer:**

**Vertical speed** = 6.3 ms$^{-1}$
**Horizontal speed** = 14 ms$^{-1}$

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

What maximum height does the rider and motorbike reach above the launch position?

taking up as positive
vertically, $u = 6.339$,
$a = -10$,
$v = 0$ (at the top), $s = ?$
$v^2 = u^2 - 2as$
$0 = 6.339^2 - 2 \times -10s$
$s = 6.339^2 \div 20$
$= 2.009$ m
OR
use the height formula $H = U^2 (\sin \theta)^2/2g$
$= 15^2 \times (\sin 25°)^2 \div 20$
$= 2.0$ m

**Answer:**
2.0 m

The dirt track dips immediately after the bump and then levels out again 19 m from, and at the same height as, the launch position.

**QUESTION 6** **3 marks**

For what length of time is the rider and motorbike in the air?

Time to the top of the motion:
$v = u + at$
$0 = 6.339 - 10t$
$t = 6.339 \div 10$
$= 0.6339$ s
time of flight $= 2 \times 0.6339 = 1.2679$
OR use the time formula $T = 2U \sin \theta/g$
$= 2 \times 15 \times \sin 25° \div 10$
$= 1.3$ s

**Answer:**
1.3 s

**QUESTION 7** **3 marks**

Perform a calculation to determine if the rider and motorbike will make it onto the flat section of track after their trip through the air?

Horizontally, $u = 13.595$, $t = 1.3$, $a = 0$, $s = ?$
$s = ut + \frac{1}{2} at^2$
$s = 13.595 \times 1.2679 + 0$
OR use the range formula $R = U^2 \sin 2\theta/g$
$= 15^2 \sin 50° \div 10$
$= 17.237$ or $17.236$ m

**Answer:**
Won't make it.

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

Later as the motorbike rider continues along a flat section of track, he accelerates from a speed of 7 $ms^{-1}$ to 12 $ms^{-1}$ in 3 seconds. What is the magnitude of his acceleration?

$u = 7$, $v = 12$, $t = 3$, $a = ?$
$v = u + at$
$12 = 7 + 3a$
$3a = 5$
$a = 1.67$ $ms^{-2}$

**Answer:**
1.67 $ms^{-2}$

An air track glider of mass 110 g is travelling along an air-track with a speed of 0.5 $ms^{-1}$. The air track has spring loaded buffers at each end enabling the glider to rebound with negligible loss of speed.

**QUESTION 9** **3 marks**

If the spring constant of the buffers is 420 $Nm^{-1}$, by how much does each spring buffer compress during a rebound? Give your answer in mm.

The energy conversion involved is kinetic to elastic potential.
$\frac{1}{2} mv^2 = \frac{1}{2} kx^2$
$\frac{1}{2} \times 0.110 \times 0.50^2 = \frac{1}{2} \times 420 \times (x)^2$
$0.01375 = 210 x^2$
$x = 0.00809$ m
$= 8.09$ or $8.1$ mm

**Answer:**
8.1 mm

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

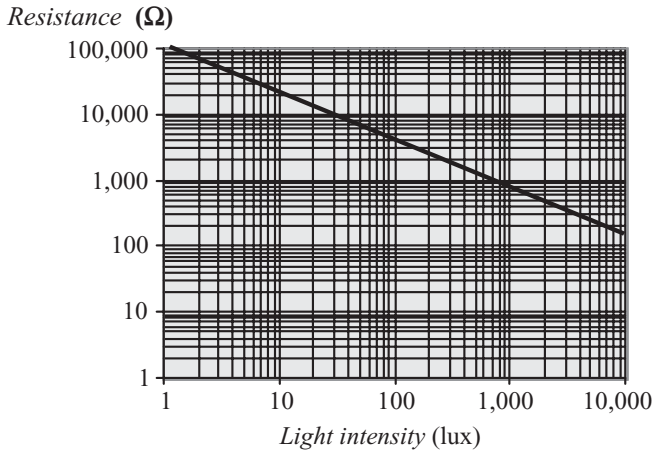
Use the following data to calculate the force of attraction between the Earth and the Sun.

- mass of the Earth $= 5.98 \times 10^{24}$ kg
- mass of the Sun $= 1.98 \times 10^{30}$ kg
- distance from the centre of the Earth to the centre of the Sun $= 1.50 \times 10^{11}$ m

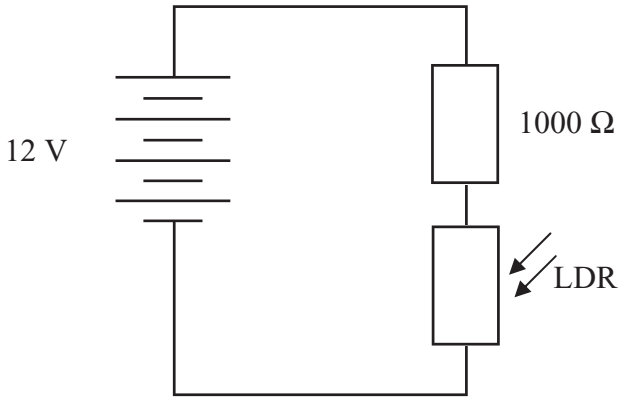
$F = G m_{Sun} m_{Earth}/r^2$
$= (6.67 \times 10^{-11} \times 1.98 \times 10^{30} \times 5.98 \times 10^{24})$
$\div (1.50 \times 10^{11})^2$
$= 3.51 \times 10^{22}$ N

**Answer:**
$3.51 \times 10^{22}$ N

Charlotte is using a light dependent resistor (LDR) in series with a 1000 Ω resistor in a voltage divider circuit to measure the light intensity inside a greenhouse. Below is the resistance versus light intensity graph for the LDR.




The circuit is connected to a 12 V battery as shown below.




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

What is the light intensity when the resistance of the LDR is 10 000 Ω?

**Answer:**

30 lux

On the *y*-axis, locate 10 000 Ω. Go across to the line on the graph. Go down to the *x*-axis and read the light intensity as 30 lux.

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

At this illumination, what is the voltage drop across the LDR?

$V_{LDR} = R_2/(R_1 + R_2)V_{in}$
$= 10000 \div (1000 + 10000) \times 12$
$= 10000/11000 \times 12$
$= 10.9$ V

**Answer:**

10.9 V

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

What amount of current flows in the circuit at this illumination? Give your answer in mA.

$I = V/R$
$= 12 \div 11000$
$= 0.00109$ A
$= 1.09$ or 1.1 mA

**Answer:**

1.1 mA

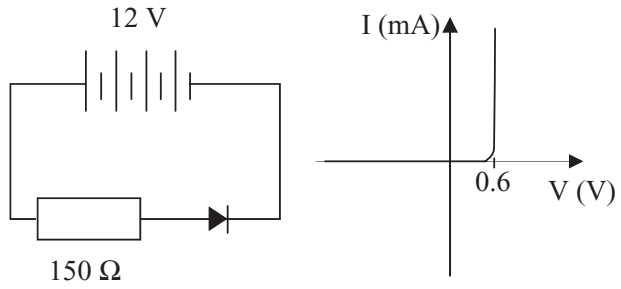
**QUESTION 14** **3 marks**

As the light intensity increases, does the voltage across the LDR increase or decrease? Explain your answer with specific reference to the graph and the circuit diagram.

**Answer:**

The graph shows that as the light intensity increases, the resistance of the LDR decreases. In the circuit diagram, as the resistance of the LDR decreases, the voltage drop across the LDR also decreases.

The circuit diagram below shows a diode connected in series with a resistor. The graph on the right shows the I−V characteristic for the diode.




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

For the circuit above, calculate the voltage across the 150 Ω resistor.

$V_R = 12 - 0.6$
$= 11.4$ V

**Answer:**

11.4 V

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

Calculate the current flowing through the diode in milliamps.

$I = V \div R$
$= 11.4 \div 150$
$= 0.076$ A
76 mA

**Answer:**

76 mA

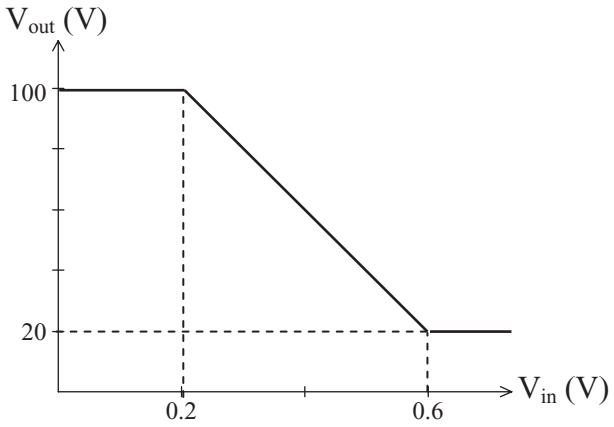
**QUESTION 17** **2 marks**

If the polarity of the battery is reversed, practically no current flows in the circuit. Explain why no current flows.

**Answer:**

If the polarity of the battery is reversed, the diode becomes reverse biased. Reverse biased diodes do not conduct, so no current flows in the circuit.

The transfer characteristic for a typical voltage amplifier is shown below.




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

Use the transfer characteristic above to calculate the voltage gain of the amplifier.

gain $= \Delta V_{out} \div \Delta V_{in}$
$= 80 \div 0.4$
$= 200$

**Answer:**

200

**QUESTION 19** **2 marks**

Is this amplifier an inverting or non-inverting amplifier? Explain your reasoning.

The slope of the transfer characteristic graph is negative.

OR

A rise in the input voltage produces a drop in the output voltage.

**Answer:**

Inverting

**QUESTION 20** **2 marks**

What are the input and output voltages at the quiescent point?

The quiescent point is the centre of the sloping section of the amplifier graph. The coordinates of this point are (0.4, 60).

$V_{input} = 0.4$ V; $V_{output} = 60$ V

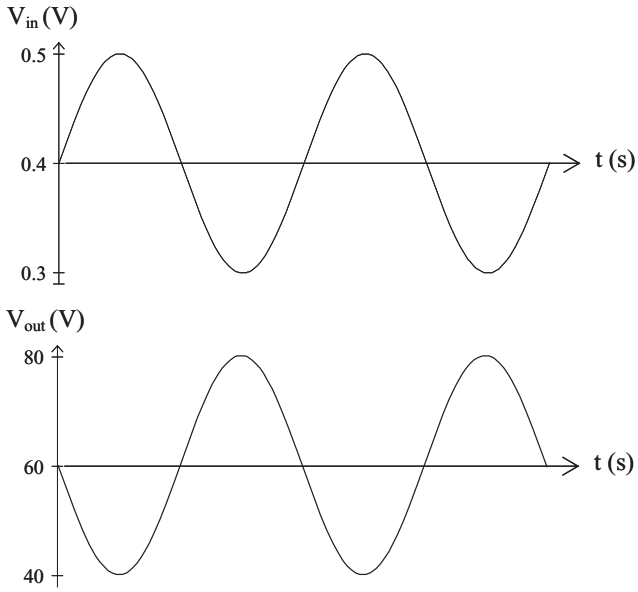
**Answer:**

$V_{input} = 0.4$ V

$V_{output} = 60$ V

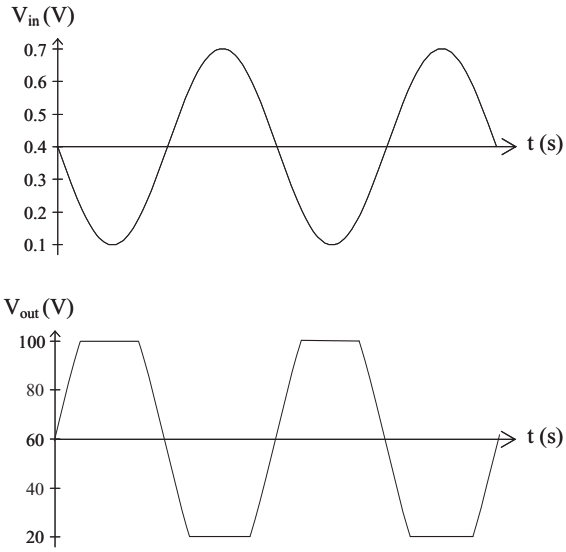
**QUESTION 21** **2 marks**

The following input voltage signal is fed into the amplifier. On the blank axes below, sketch the corresponding output voltage signal produced by the amplifier.




**QUESTION 22** **2 marks**

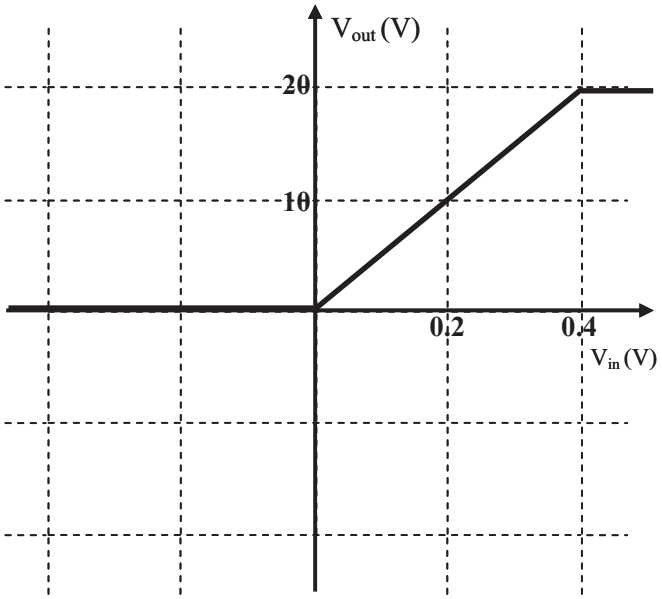
The following input voltage signal is fed into the amplifier. On the blank axes below, sketch the corresponding output voltage signal produced by the amplifier.



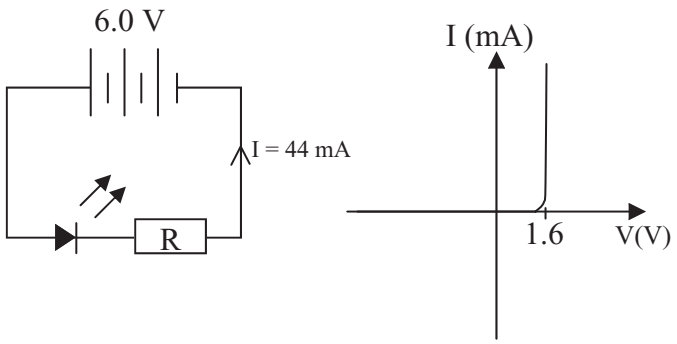
**QUESTION 23** **3 marks**

On the blank axes below, sketch the transfer characteristic for a voltage amplifier with the following qualities:

- non-inverting with a gain of 50
- input voltage at the quiescent point of 0.2 V
- output voltage at the quiescent point of 10 V
- input voltage range of 0 to 0.4 V




The circuit diagram, below left, shows an LED connected in series with a limiting resistor. The graph on the right shows the I−V characteristic for the LED.




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

For the circuit above, calculate the voltage across the resistor.

$V_R = 6.0 - 1.6$
$= 4.4$ V

**Answer:**

4.4 V

**QUESTION 25** **2 marks**

Calculate the value of the resistor $R$.

$R = V \div I$
$= 4.4 \div (44 \times 10^{-3})$
$= 100\ \Omega$

**Answer:**

100 Ω

**QUESTION 26** **2 marks**

Calculate the power output of the LED.

$P_{LED} = V \times I$
$= 1.6 \times 44 \times 10^{-3}$
$= 0.0704$ W or 0.07 W

**Answer:**

0.07 W