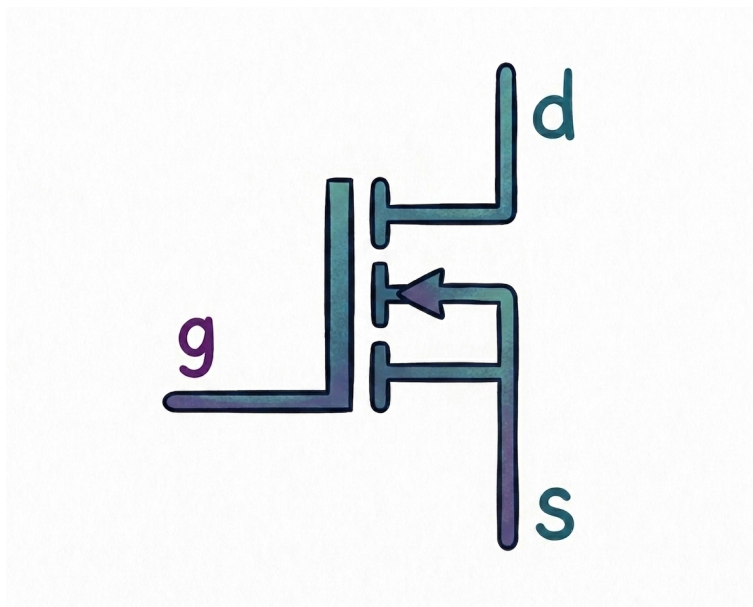


Topic 105 Semiconductor Devices Question Pack

for

Eduqas GCE A-Level Electronics



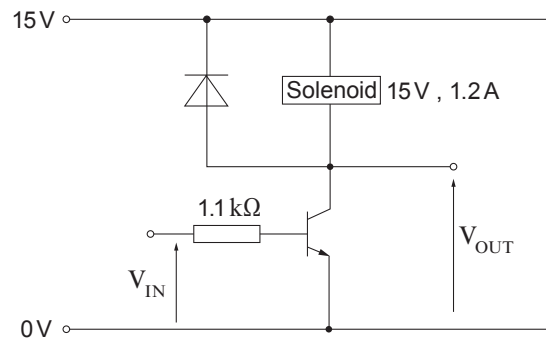
Student Name:

Class / Group:

Question 1

14

8. The transistor switching circuit shown is used to operate a solenoid.



The transistor has a current gain, $h_{FE} = 240$.

- (a) The value of V_{IN} is sufficient **just** to saturate the transistor. Calculate:

(i) the base current,

[2]

.....

.....

(ii) the value of V_{IN} .

[2]

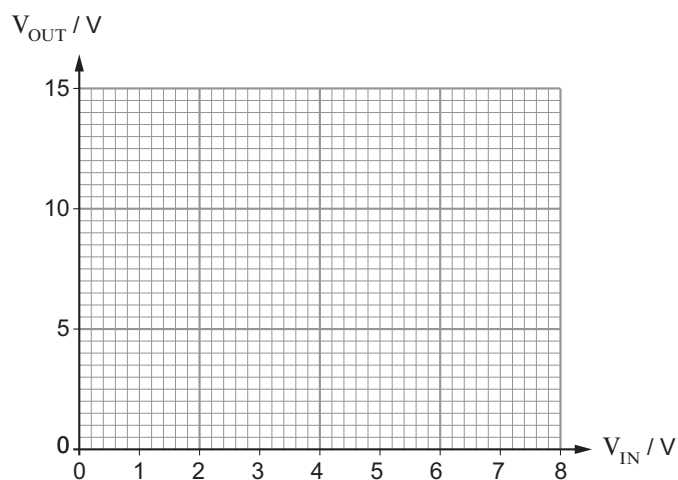
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- (b) Draw a graph to show how V_{OUT} changes as V_{IN} is increased from 0 to 8 V.

[3]

Examiner
only

- (c) (i) Use the graph to determine the value of V_{OUT} when $V_{IN} = 4.4$ V.

[1]

- (ii) Explain the effect this value of V_{OUT} would have on the operation of both the transistor and the solenoid.

[2]

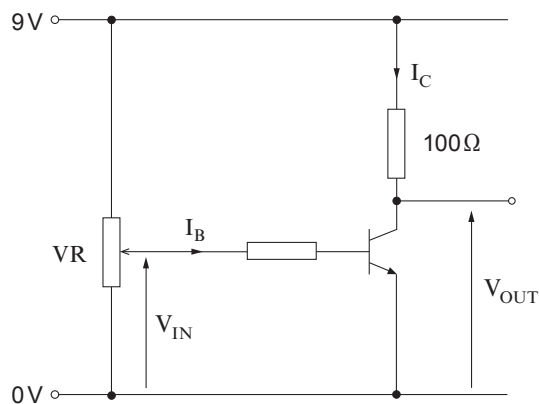
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Question 2

14

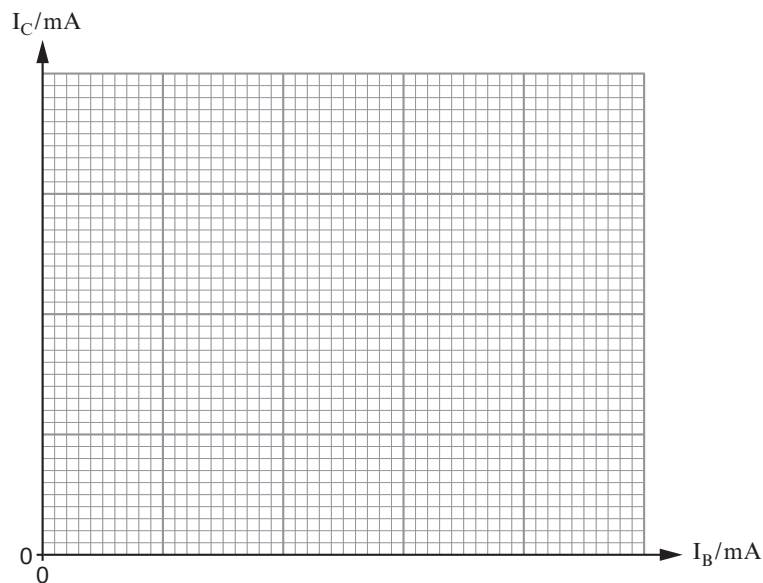
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6. The following circuit is set up to investigate a transistor switching circuit.



The output of the potentiometer VR is varied and readings of I_B , I_C , V_{IN} and V_{OUT} are taken.

- (a) As the base current is increased from 0.1 to 0.4 mA the collector current increases from 14 to 68 mA and the transistor does not saturate.
- (i) Complete the graph below to show how I_C changes as I_B is increased from 0 to 0.45 mA. Label both axes with a suitable scale. [2]

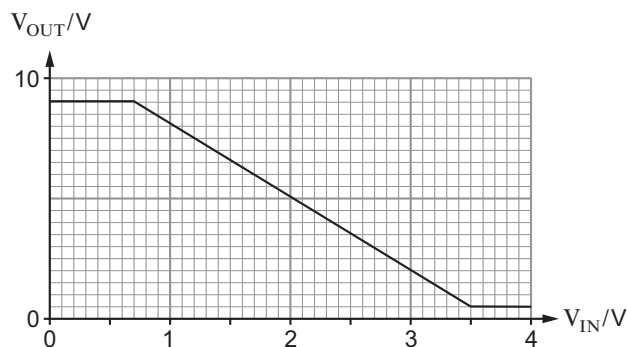


- (ii) Determine the current gain (h_{FE}) of the transistor. [1]

.....

.....

- (b) A second graph shows how V_{OUT} changes as V_{IN} is increased from 0 to 4 V.



Use the graph to determine:

- (i) The minimum value of V_{IN} required to saturate the transistor. [1]

.....

- (ii) The value of V_{OUT} , when $V_{IN} = 1.5 V$ and the load resistor is 100Ω . [1]

.....

- (c) $V_{IN} = 1.5 V$ and the load resistor is 100Ω .

Calculate the collector current **and** the power dissipated in the transistor. [3]

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Question 3

18

8. The block diagram shows a design for a fan cooling system for a desktop PC.

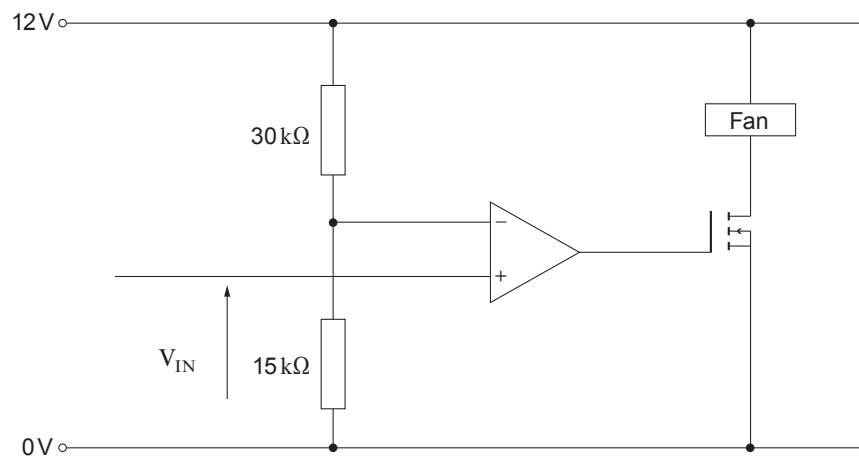
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The fan which is rated at 12 V, 72 W should operate when the air temperature in the PC housing is more than 30 °C.

- (a) Complete the circuit diagram for the system by adding:

- the temperate sensing sub-system
- a component to protect the MOSFET when the fan switches off

[3]



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- (b) Calculate the minimum value of V_{IN} at which the fan will operate.

[1]

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- (c) The MOSFET has the following parameters:

- maximum power dissipation = 60 W
- $r_{DSon} = 0.25\Omega$

Calculate the power dissipated in the MOSFET when the fan is operating at its rated current.

[3]

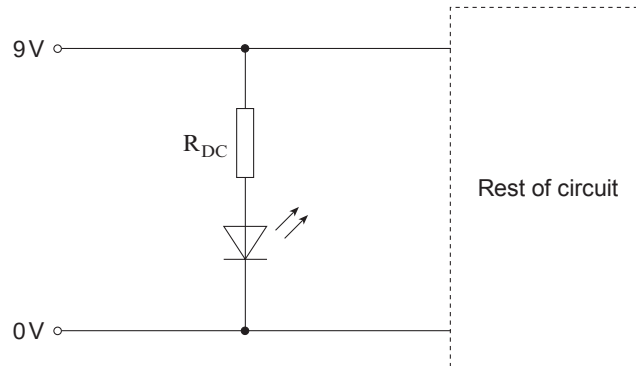
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Question 4

6

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3. A power-on indicator for a DC circuit is shown below.



- (a) (i) The forward voltage drop across the LED is 2V. Calculate the value of R_{DC} , required to limit the current through the LED to a maximum of 20mA.

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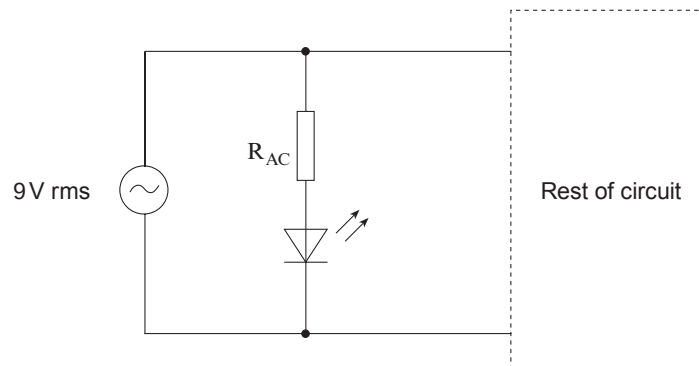
- (ii) Select the preferred value for R_{DC} from the E24 series.

.....

[3]

- (b) A power-on indicator is needed for a 9V rms AC circuit.

- (i) Complete the circuit diagram by adding a component to protect the LED from the reverse polarity of the AC supply.



- (ii) Determine the value of R_{AC} required to provide approximately the same level of illumination as the DC **power-on** indicator.

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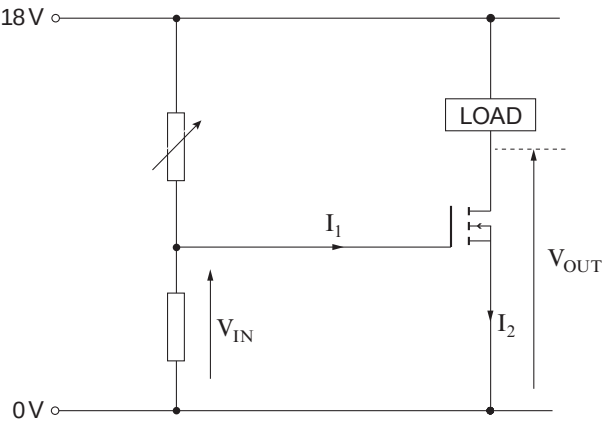
[3]

Question 5

8

5. An engineer sets up the following circuit to check some parameters of a MOSFET.

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The variable resistor is adjusted until the MOSFET is just saturated. The following results are obtained.

V_{IN} / V	V_{OUT} / V	I_2 / A
4.5	1.3	10.8

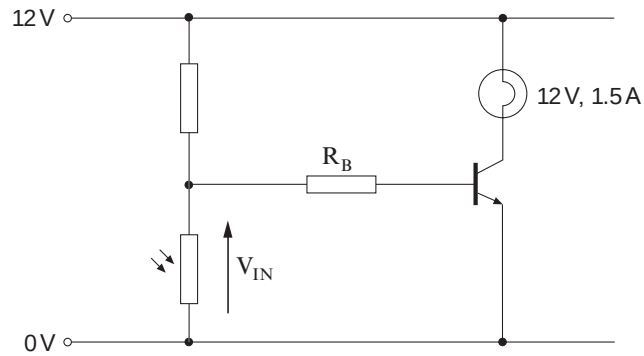
- (a) Estimate the value of I_1 when the load current is 10.8A. [1]
- (b) Use the results provided in the table to calculate the value of r_{DSon} . [1]
-
-
- (c) Calculate the power dissipated in the MOSFET when the load current is 10.8A. [1]
-
-
- (d) An interface is required to connect a logic system with a maximum available output current of 40mA to a 20A load. Explain why a MOSFET would be a better choice than an npn transistor for this application. [2]
-
-
-

Question 6

14

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8. A system is required to switch on a lamp in a small display cabinet when the light level falls to 100 lux. The initial design uses the following circuit.



The transistor has a current gain of 500 ($h_{FE} = 500$).

- (a) The input voltage V_{IN} is 5.2V and the transistor is just saturated.

Determine:

- (i) the base current [2]

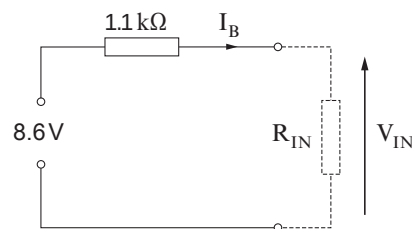
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- (ii) the value of the base resistor R_B . [2]

.....

- (b) There is a concern that the circuit will not function correctly due to the transistor input loading the light sensing sub-system.

The Thevenin equivalent circuit for the light sensing sub-system at an illumination level of 100 lux is shown connected to the transistor input R_{IN} .



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Use the equivalent circuit to show by calculation whether the transistor is saturated at 100 lux.

[Hint: You will need to consider whether the **new voltage** V_{IN} , is sufficient to saturate the transistor when providing the base current calculated in part (a) opposite.] [3]

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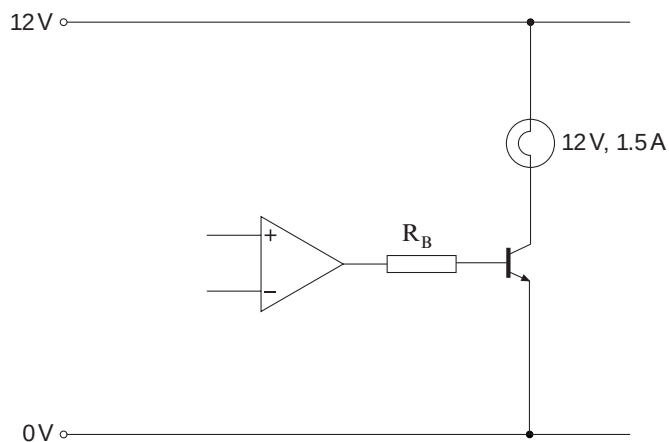
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(c) The system design is improved by adding a comparator sub-system.



Complete the circuit diagram for the system by adding:

- the light sensing sub-system;
- the component(s) required to provide a reference voltage sub-system;
- a facility for adjusting the light level at which the lamp comes on.

[3]