Biomedical Admissions Test (BMAT)

Section 2: Physics

Questions by Topic

P3: Mechanics

P3: Mechanics - Question by Topic

Mark scheme and explanations at the end

1 A car with mass 1000kg is travelling at 25m/s when it collides with a wall. It is brought to rest in 100ms.

What is the force exerted on the car by the wall?

A 250 N
B 250,000 N
C 2500 N
D 25000 N
E None of the above

2 Which of the following statements apply to acceleration?

1 It can be calculated by the area under the line of a velocity-time graph.
2 The unit for acceleration is equivalent to $JN^{-1}s^{-2}$.
3 Acceleration is the rate of change of velocity.

A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D All of the statements

3 What is the work done by a force of 20kN acting on an object over the distance of 0.1km?

A 2000J
B 20KJ
C 200KJ
D 2MJ

Questions 4-6 refer to the following information:
An electric motor lifts a 15kg object 20m vertically upwards over a time period of 5 seconds. The object is then released and allowed to fall to the ground. For the purpose of these questions you may assume that acceleration due to gravity=10ms^{-1}, air resistance is negligible and the motor is 100% efficient.

4 What is the gain in gravitational potential energy of the object?

A 300J
B 3000J
C 2000J
D 20000J

5 What is the power of the motor?

A 115W
B 230W
C 0.46KW
D 600W

6 What was the speed of the object as it hit the ground?

A 5 ms^{-1}
B 10 ms^{-1}
C 20 ms^{-1}
D 25 ms^{-1}

7 Which of the following statements is true?

A Gravitational energy of an object is independent of its mass.
B Two objects of the same mass dropped from the same height will always hit the ground at the same time.
C Terminal velocity is reached when air resistance is equal to the falling object's mass
D None of the above

8 A petrol powered generator is 50% efficient and uses 1 gallon of petrol per hour. Given that 1 gallon of petrol contains $9x10^8$J of energy, how much electrical power does the generator produce per hour?

A 1250W
B 25KW
C 250KW
D 125KW

Solutions

1 B is the answer

When you are confronted by a question, like this one, that contains many different values and asks you to calculate an answer, don't worry if you can't see what to do at first.

Initially, just identify what **values** you are **given**, and what you need to **calculate**:
Mass, speed, time taken to come to rest, and force.

Next, **recall equations** you know involving these values:

$$Momentum = mass \times velocity$$
$$Force = change\ in\ momentum \div time$$
$$Force = mass \times acceleration$$

A possible method to obtain the solution from these equations is as follows:

$Momentum = mass \times velocity$:

$$1000kg \times 25ms = 25000kgms$$

$Force = change\ in\ momentum \div time$:

$$25000 \div 0.1 = 250,000N$$

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2 C is the answer

This question is solvable by recalling the information shown in velocity time graphs and rearranging the following equation:

$$Work\ done = force \times distance$$

Statement **1** is incorrect - the **area under a velocity-time graph** is the **distance** travelled. If you cannot recall this, you can work it out by realising that the area under the graph is calculated by multiplying velocity and time, and this is equal to displacement (distance).

*Statement **2** is correct - it can be found by rearranging the above equation:*

$$Distance = work\ done \div force$$

Therefore $JN^{-1}s^{-2}$ is equivalent to ms^{-2}

*Statement **3** is correct - acceleration is defined as the rate of change of velocity.*

Exam Tip - Questions that ask you to find equivalent units can be challenging.

Sometimes you see the answer immediately, but sometimes you don't. It is important **not to spend too much time** on these questions if you cannot find the answer. Move on, and **come back to it at the end if you have time**!

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3 D is the answer

While this seems to be a fairly straightforward question, it is easy to get confused with the orders of magnitude when converting units:

$$Work\ done = force \times distance$$

$$Work\ done = 20000N \times 100m = 2,000,000J = 2MJ$$

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4 B is the answer

This Question can be answered by using the equation for gravitational potential energy:

$$GPE = mass \times gravity \times height\ gained$$

$$GPE = 15Kg \times 20m \times 10NKg^{-1} = 3000J$$

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5 D is the answer

This question can be solved by using the equation for power and knowing that the motor is 100% efficient.

By knowing that the motor is 100% efficient you know that the energy supplied by the motor is equal to the gain in gravitational potential energy calculated above:

$$Power = work\ done \div time = 3000J \div 5s = 600W$$

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6 C is the answer

This question can be solved by first realising that as the object falls, all of the gravitational potential energy stored in the object is converted to kinetic energy as it falls (as air resistance is negligible). This means you can equate and rearrange the following equations:

$$Gravitational\ potential\ energy = Kinetic\ energy$$
$$Mass \times gravity \times height = 0.5 \times mass \times velocity^2$$
$$Velocity = \sqrt{2 \times gravity \times height}$$
$$Velocity = \sqrt{2 \times 10 \times 20} = 20 m/s$$

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7 **D is the answer**

Statement 1 is proved incorrect by recalling the equation for GPE:

$$GPE = mass \times gravity \times height$$

Therefore GPE is dependent on the object's mass.

Statement 2 is incorrect as two objects of the same mass dropped at the same time will not always hit the ground at the same time. Other factors such as air resistance are involved which makes the object's volume and surface area important factors to consider.

Statement 3 is incorrect as terminal velocity is reached when drag force = object's **weight**

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8 **D is the answer**

The difficulty in this question is due to the nature of the large numbers and long division involved It is solved by using the following equations and knowing the generator has an efficiency of 50%:

$$Power = energy\ used \div time$$
$$Efficiency = useful\ power\ output \div total\ power\ input$$

$$Power = 9 \times 10^8 \div 3600 = 250000 W$$
$$Electrical\ power\ output = 250000 W \times 0.5 = 125000 W = 125 kW$$