



WESTMINSTER SCHOOL  
THE CHALLENGE 2023  
**PHYSICS**

Thursday 27 April 2023

**Time allowed: 30 minutes**

**Please write in black or blue ink.**

**Calculators are allowed.**

**Write your answers in the spaces provided.**

**For examiner use only**

Total		
Mark		

This paper starts with mostly multiple choice questions and ends with one longer question asking you to design an experiment. The multiple choice questions are hard. Do not be intimidated but rather enjoy the challenge!

**Data:**

Speed of light  $c$   $3.00 \times 10^8$  m/s

1. The kinetic energy of a mass  $m$  travelling at speed  $v$  is given by  $\frac{1}{2} m v^2$ . A 20,000 kg truck is traveling at 25 km/hr. At what speed does a 1000 kg car need to travel to have the same kinetic energy as the truck?  
  
A 112 km/hr  
B 132 km/hr  
C 102 km/hr  
D 79.0 km/hr  
E 89.0 km/hr
  
2. Who was the **last** person to walk on the Moon?  
  
A Buzz Aldrin  
B Eugene Cernan  
C Neil Armstrong  
D Sally Ride  
E Christa McAuliffe
  
3. Two forces have magnitudes of 11.0 N and 5.0 N. They could be pointing in any direction. The magnitude of their sum could **NOT** be equal to which of the following values?  
  
A 16.0 N  
B 9.0 N  
C 7.0 N  
D 5.0 N  
E 6.0 N
  
4. Which of the following colours of visible light has the **longest** wavelength?  
  
A Violet  
B Yellow  
C Blue  
D Green  
E Red

5. When descending mountain roads, large trucks pulling a heavy load can burn up the brakes. Once the brakes are no longer useful, the driver may need to guide the truck up a “runaway truck escape lane” at the side of the road. The runaway truck escape lane is directed uphill and often has a thick layer of sand or gravel on the surface. Which of the following is the most likely reason that the truck will stop in the escape lane?

- A An increase in the truck’s kinetic energy
- B A decrease in the truck’s gravitational potential energy
- C A decrease in the truck’s fuel
- D A transfer of energy to the gravel on the track of the runaway truck lane
- E The change in temperature of the engine

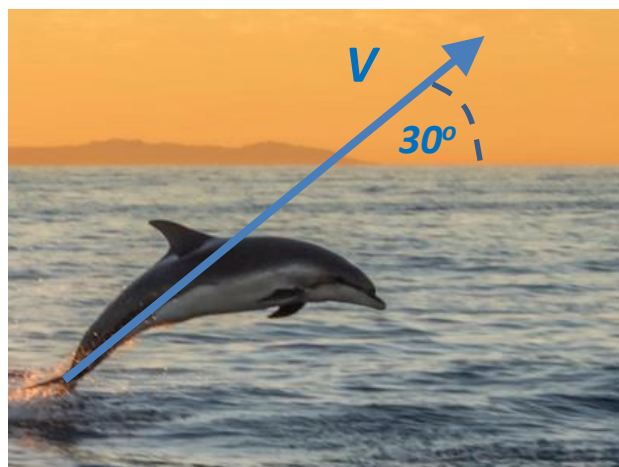
6. The James Webb Space Telescope was launched on December 25, 2021 and arrived at its destination, LaGrange Point 2, on January 24, 2022. This point is approximately 1,500,000 km from the Earth and it is where the telescope will orbit the sun.

Radio signals travel at the speed of light. How long will it take the radio signal sent by the James Webb Space Telescope to reach the Earth?

- A 0.005 s
- B 0.05 s
- C 5 s
- D 50 s
- E 5000 s

7. A fisherman watches a dolphin leap out of the water at speed  $V$  at an angle of  $30^\circ$  above the horizontal. The horizontal component of the dolphin’s velocity is 7.7 m/s. Find the magnitude of the vertical component of the velocity.

- A 3.2 m/s
- B 4.4 m/s
- C 5.4 m/s
- D 6.3 m/s
- E 11 m/s



8. A metallic wire's electrical resistance is proportional to its length and inversely proportional to its cross-sectional area. If a copper wire **of fixed volume** is stretched to make it 1% longer, what is the percentage change in its resistance?

- A 0.1%
- B 1%
- C 2%
- D 4%
- E 5%

9. A block of wood initially at rest slides down a slope. Neglecting friction, the kinetic energy of the block at the bottom of the plane is

- A all converted into heat
- B less than its kinetic energy at the top of the slope
- C dependent on the materials of which the block is made
- D dependent on the materials of which the slope is made
- E equal to its change in gravitational potential energy between the top and bottom of the slope

10. This question is about objects that move at constant speed along circular paths (this is called uniform circular motion). The magnitude of the centripetal acceleration  $a_c$  of an object on a circular path is given by

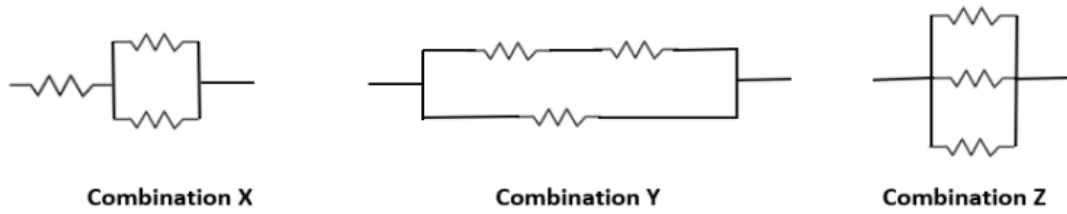
$$a_c = v^2 / r$$

where  $v$  is the speed of the object, and  $r$  is the radius of the circle.

- a) Explain why objects are accelerating as they go around circular paths, even though they are moving at constant speed.
- b) "Jerk" is the rate of change of acceleration. For uniform circular motion, the magnitude of the jerk is given by:

- A zero
- B  $v^2 / r$
- C  $v^2 r$
- D  $v^3 / r$
- E  $v^3 / r^2$

11. The diagram below shows combinations X, Y, and Z of three identical resistors.

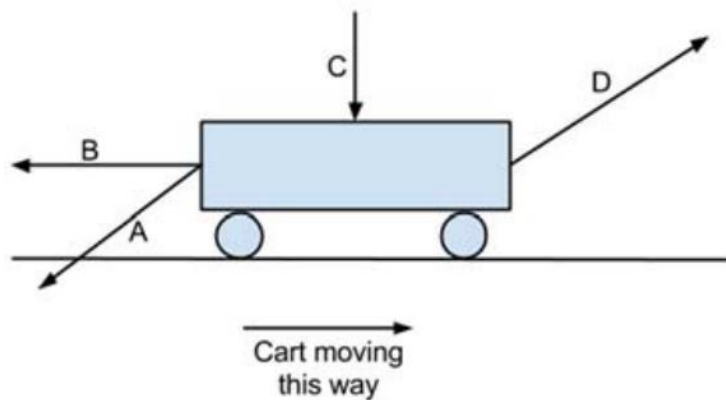


What is the correct order of the total resistance of the combinations going from lowest resistance to highest resistance?

- A Y, X, Z
- B Z, X, Y
- C X, Y, Z
- D Z, Y, X
- E Y, Z, X

12. When a force does work on an object, energy is transferred to or from the object.

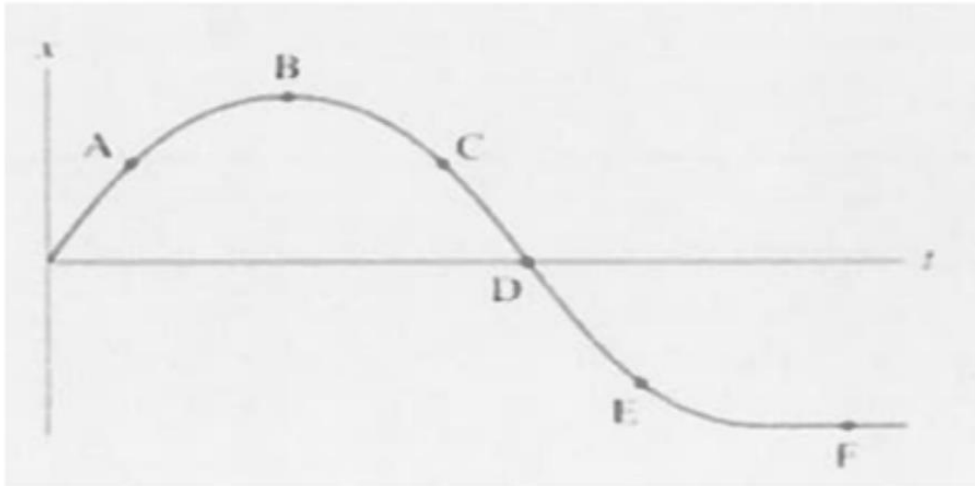
A force,  $F$ , could be applied to a cart in a variety of directions as shown.



Which of the applications of  $F$  would result in no work being done?

- A A
- B B
- C C
- D D
- E All of them result in work being done

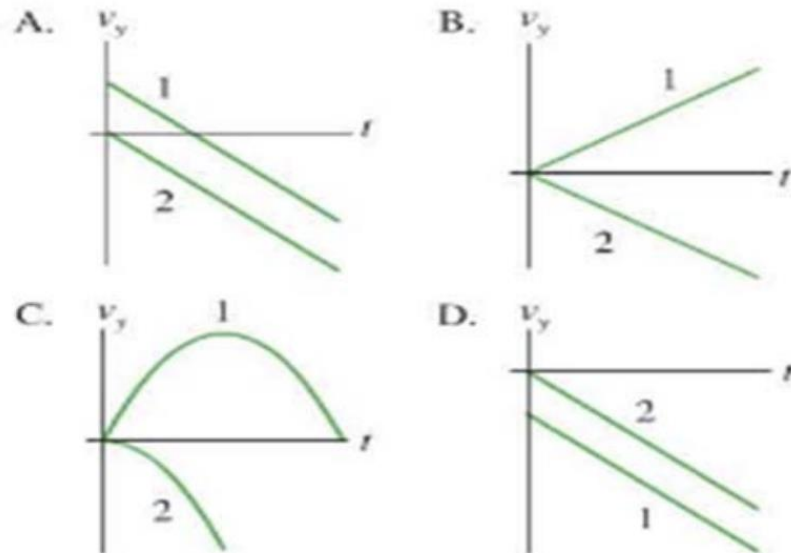
13. The figure shows the position-time graph of an object traveling in a straight line, starting out moving to the right (the positive x-direction).



At which points is the object moving to the left?

- A      B and F
- B      E and F
- C      A, B, and C
- D      C, D, and E
- E      None of the above

14. At time  $t = 0$  seconds, ball 1 is rolling up a ramp and ball 2 is released from the top of the same ramp. The balls do not collide. Which graph for velocity against time best represents the motion of the two balls?



- A     A  
 B     B  
 C     C  
 D     D  
 E     Both A & D

15. You are given three 6 ohm resistors. Neglecting the resistance of any connecting wires, which of the following resistances **CANNOT** be made using **one or more** of these resistors?

- A     2 ohms  
 B     3 ohms  
 C     9 ohms  
 D     12 ohms  
 E     15 ohms

16. Disposable coffee cups are made of a variety of materials.  
One requirement of a good coffee cup is to keep drinks hot for a longer time.



Outline an experiment to investigate and compare the effectiveness of two coffee cups, one made with corrugated cardboard and the other with expanded polystyrene. ***Please write your answer on the opposite page.***

You should include the following:

- Labelled diagram
- Variables being measured and controlled
- Appropriate measuring instruments
- Safety precautions
- Experimental details to improve the accuracy and validity of the results
- A graph of the results you expect



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