2019 Year 11 Physics

Task 10: Test 5 – Motion

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. Speedway programs often include an event called a "demolition derby". In this event, the cars, which are usually older models of conventional makes, race each other. The difference is that the drivers can deliberately collide. The idea is to damage an opponent’s car and force it from the race, hence "demolition derby".

The following scenario is unlikely - all cars travel in the same direction around the track - but not impossible.

'Tripped out Tyler’s car of mass 1.200 x 103 kg and travelling at 60.0 km h-1 collides head on with 'Crazy Contano’s car of mass 2.000 x 103 kg, which is also travelling at a speed of 60 km h-1, but in the opposite direction.

1. What force does each car experience? Explain your reasoning. (No calculation needed).

Each car has an equal and opposite force applied to them \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(1 Mark)

b) Would each car come to rest immediately after the collision? Explain your reasoning.

Assuming it is an inelastic collision No (1 mark). Darian’s car has more momentum and both will continue in its original direction, at a lower speed (1 mark).

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(2 Marks)

c) Which of the two drivers is more likely to suffer whiplash injuries? Explain your reasoning.

Tyler will undergo more whiplash. (1 mark) Tyler’s car has a greater velocity change, therefore greater acceleration and a greater force is applied to him. (1 mark) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(2 Marks)

d) In such a potentially dangerous event, what safety features do drivers include in their cars to protect them in the inevitable collisions?

Seatbelts, roll cages, crumple zones, anti-lock brakes. (not airbags). Name 2 for (1 mark) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(1 Mark)

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2. Starting from rest, Quinlan gets into his car and ends up in a lane where he travels over a long, straight but arched bridge. The bridge spans a distance of 100.0 m but has an arched length of 115.0 m . His car accelerates to a speed of 65.0 km h-1 which is the speed that he maintains for the remainder of the drive across the bridge. It takes 8.50 s to cross the bridge, calculate:

1. His average speed across the bridge.

s = d/t = 115 / 8.5 d = 115m t = 8.5 sec (1 mark)

= 13.5 m/s (1 mark) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(2 Marks)

b) His average velocity across the bridge.

v = s / t = 100/8.5 s = 100m t = 8.5 sec (1 mark)

= 11.8m/s over the bridge (1 mark)

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(2 Marks)

3. Andrey, while running, can accelerate from rest to a velocity of 15.0 ms-1 in the same time that Monique, driving a car can accelerate from 70 km h-1 to 85 km h-1. Which person has the greatest acceleration?

Time period, same as both, set t = 1 second

Andrey a = v /t = 15.0 / 1 = 15 m/s2 (1 mark)

Monique: convert Δv in km/h to m/s Δv = 15km/s -> 4.67 m/s (1 mark)

a = v / t = 4.67 m/s2 (1 mark)

Therefore Andrey has the greatest acceleration (1 mark)

(4 Marks)

4. Josh is horrendously injured at the base of the cliff and needs to be rescued by the State Emergency Service (SES). To retrieve him they use a pulley system set up at the top of the cliff. It consists of the pulley, a drive wheel and a cable and hook to lift Josh to a point where he can be raised to the top of the cliff.

Pulley



Drivewheel

Josh

A cable running over a single pulley as shown in the diagram above supports the Josh, who has a mass of 75 kg.

a) What would be the tension in the cable if Josh is raised at a constant velocity of

2.0 m s-1.

F = m x g m = 75 kg g = 9.81m/s2

= 75 x 9.81 (1 mark)

= 735 N (1 mark)

(2 Marks)

b) What would be the tension in the cable if Josh is raised at an acceleration of 2.0 m s-2

F = m x aT m = 75 kg aT = g + a = (9.81 + 2)

= 75 x 11.81 (1 mark)

= 886 N (1 mark)

(2 Marks)

5. Why is the force you need to apply to the pedals of a bicycle less if you begin your ride on a downwards slope?

Because gravity acts partly in the direction of the slope, a component of the gravitational force acts in the direction that you are going. (1 mark)

(1 Mark)

6. If you are involved in a traffic crash, is it safer for you (and the other driver) if your two cars stick together or bounce apart in the crash? Explain.

Damage to people occurs when there are forces applied to them. Larger forces occur when there are large accelerations. (1 mark)

If cars bounce apart it means their velocity change needs to be higher than if the cars stick together, the higher velocity change over the same time means a higher acceleration, therefore it is safer when cars stick together. (1 mark)

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(2 Marks)

MCBD07308_0000[1]7. Some physics students who were investigating the velocity of a moving car, which was initially at rest, tabulated their results for the first 6 seconds of the car's motion in the table below.

|  |  |  |
| --- | --- | --- |
| Time (s) | Velocity (m s-1) | Displacement (m) |
| 0 | 0 | 0 |
| 1 | 2 | 1 |
| 2 | 4 | 4 |
| 3 | 6 | 9 |
| 4 | 6 | 15 |
| 5 | 6 | 21 |
| 6 | 6 | 27 |

a) Plot a graph of velocity versus time on the paper provided.

Required: Title, label & units x axis, label & units y axis, correctly graphed

(2 Marks)

b) From the graph, calculate the car’s acceleration after 2 s.

From graph: Δv = 4 m/s, t = 2sec

a = Δv / t

= 4 / 2

= 2 m/s2 (1 mark)

(1 Mark)

c) From the graph, calculate the total displacement of the car after 6 s.

Area under the graph

0.5 x (0 + 2) x 1 + 0.5 x (2 + 4) x 1 + 0.5 x (4 + 6) x 1 + 6 x 3 = 27 m \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(1 mark)

d) Complete the table by calculating displacements for each second of it’s travel.

See above \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(2 marks)

e) Plot a graph of displacement versus time on the paper provided.

(2 Marks)

Required: Title, label & units x axis, label & units y axis, correctly graphed

8. Mr M is driving a 10.0 tonne truck travelling at 45.0 km h-1 when it collides with Dante in a stationary car. The car has a mass of 1.50 x 103 kg.

1. Calculate the kinetic energies of both vehicles before the collision.

EK = ½ mv2 truck: mT = 10,000kg vT = 45/3.6 = 12.5 m/s (1 mark)

Car: MC = 1500 kg vC = 0 m/s

EK.T = ½ x 10000 x 12.52

= 7.81 x 105J (1 mark)

EK.C = ½ x 1500 x 02

= 0J (1 mark)

(3 marks)

b) If, as a result of the collision, the truck is stopped but the car moves at 45.0 km h-1 in the initial direction of the truck, has the total kinetic energy of the system been conserved? You need to show how you arrived at your conclusion mathematically.

EK.T = ½ 10000 x 02

= 0J

EK.C = ½ 1500 x 12.52

= 1.72 x 105J

Comparing energy intial to energy final (0 + 7.81 x 105J) - (1.72 x 105J + 0) = 6.64 x 105 J (1 mark)

Energy is always conserved however not all of the energy has been transferred into the kinetic energy of the car. The energy differential may have been accounted for due to sound and crumple zones (1 mark)

(2 marks)

9. a) What factor change is there to the kinetic energy of your car if you double its speed?

EK = ½ mv2 mT = 1kg vT = 1 m/s

vC = 2 m/s (1 mark)

EK.1 = ½ x 1 x 12 = 0.5 J

EK.2 = ½ x 1 x 22 = 2 J

EK.2 / EK.1 = 2 / 0.5 = 4

There is a factor change of 4 (1 mark)

(2 marks)

b) What happens to the braking distance if the speed is doubled? You can ignore your own reaction time in this calculation and you can assume the stopping force provided by the braking system stays the same

v2 = u2+ 2as v1 = 1m/s v2 = 2m/s a = 1m/s2 u = 0 m/s

as u = 0 and we need to find s equation can be rewritten as:

s = v2 / (2a)

s1 = 12 / (2 x 1)

= 0.5 m (1 mark)

s2 = 22 / (2 x 1)

= 2 m

s2 / s1 = 2 / 0.5

= 4

There is a factor change of 4 (1 mark)

(2 marks)

10. When the force exerted on a car is not constant the work can be found from a force-displacement graph. How?

Calculating the area under the graph gives the work done in Joules

(2 marks)

11. How much work is done when a force of 500 N is exerted on a car to make it move

2.5 m in the direction of the force?

W = F x s F = 500 N s = 2.5m (1 mark)

= 500 x 2.5

= 1250 Joules (1 mark)

(2 marks)

12. For the following questions, assume the zero level of potential energy is at a convenient level. Velocities are assumed to be measured relative to the ground.

1. A tow truck hoists a 2300 kg wreck vertically by 3.0 m and horizontally by 4.0 m. By how much does the wreck's potential energy change?

EP = mgh m = 2300 kg g = 9.81 m/s2 h = 3.0m (1 mark)

= 2300 x 9.81 x 3

= 6.77 x 104 J (1 mark) (2 marks)

1. A motor bike is travelling at 5.0 m s-1 and slows to 3.0 m s-1. Its mass is 100 kg. By how much does its kinetic energy change?

EK = ½ mv2 m = 100 v1 = 5 m/s v2 = 3 m/s

EK.1 = ½ x 100 x 52 = 1250 J

EK.2 = ½ x 100 x 32 = 450 J (1 mark)

EK.1 - EK.1 = 800J (1 mark)

Change in energy is 800 Joules

(2 marks)

c) A constant force of 400 N is applied to a 50 kg cart which is pushed up a hill for a distance of 8.0 m, reaching a maximum height of 3.0 m. 100 J of energy is lost due to friction. Sketch a diagram showing this situation. What total energy is gained by the cart?

mgh = 50 x 9.81 x 3.0 = 1472 Joules

= 1.47 x 103 Joules

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(2 marks)

13. The power provided by a motor is plotted against time in the graph below. How much work was done by the motor in the first half minute?

Time (s)

1

2

3

4

0

10

20

30

40

50

Power (kW)

0.5 x (0 + 3) x 10 + 0.5 x (3 + 4) x 20 = 85 Joules \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(2 marks)