**Q1.** Three forces act on a particle. These forces are (9**i** – 3**j**) newtons, (5**i** + 8**j**) newtons and (–7**i** + 3**j**) newtons. The vectors **i** and **j** are perpendicular unit vectors.

(a)     Find the resultant of these forces.

**(2)**

(b)     Find the magnitude of the resultant force.

**(2)**

(c)     Given that the particle has mass 5 kg, find the magnitude of the acceleration of the particle.

**(2)**

(d)     Find the angle between the resultant force and the unit vector **i**.

**(3)**

**(Total 9 marks)**

**Q2.**          A car, of mass 1500 kg, is towing a caravan, of mass 900 kg, along a straight horizontal road. The caravan is connected to the car by a horizontal tow bar. Resistance forces of magnitudes 400 N and 800 N act on the car and caravan respectively. The acceleration of the car and caravan is 0.8 m s–2.



(a)     Show that the magnitude of the force that the car exerts on the caravan is 1520 N.

**(3)**

(b)     Find the magnitude of the driving force produced by the car’s engine.

**(3)**

**(Total 6 marks)**

**Q3.** A tractor, of mass 3500 kg, is used to tow a trailer, of mass 2400 kg, across a horizontal field. The trailer is connected to the tractor by a horizontal tow bar. As they move, a constant resistance force of 800 newtons acts on the trailer and a constant resistance force of *R* newtons acts on the tractor. A forward driving force of 2500 newtons acts on the tractor. The trailer and tractor accelerate at 0.2 m s–2.

(a)     Find *R*.

**(3)**

(b)     Find the magnitude of the force that the tow bar exerts on the trailer.

**(3)**

(c)     State the magnitude of the force that the tow bar exerts on the tractor.

**(1)**

**(Total 7 marks)**

**Q4.**          A car, of mass 1200 kg, tows a caravan, of mass 1000 kg, along a straight horizontal road. The caravan is attached to the car by a horizontal tow bar, as shown in the diagram.



Assume that a constant resistance force of magnitude 200 newtons acts on the car and a constant resistance force of magnitude 300 newtons acts on the caravan.
A constant driving force of magnitude *P* newtons acts on the car in the direction of motion. The car and caravan accelerate at 0.8 m s–2.

(a)     (i)      Find *P*.

**(3)**

(ii)     Find the magnitude of the force in the tow bar that connects the car to the caravan.

**(3)**

(b)     Explain why the assumption that the resistance forces are constant is unrealistic.

**(1)**

**(Total 13 marks)**

**Q5.**   A car, of mass 1400 kg, is towing a trailer, of mass 600 kg. The two vehicles accelerate together at 1.3 m s–2 along a straight horizontal road.



(a)     A forward driving force, of magnitude 3900 N, acts on the car. A resistance force, of magnitude 800 N, also acts on the car.

(i)      A resistance force, of magnitude *P* newtons, acts on the trailer. Find *P*.

**(3)**

(ii)     Find the magnitude of the force that the car exerts on the trailer.

**(3)**

**(Total 9 marks)**

**M1.**(a)     (*F* =)9**i** − 3**j** + 5**i** + 8**j** – 7**i** + 3**j** = 7**i** + 8**j**

*M1: Adding the three forces with one component correct.*

*A1: Correct answer.* M1A1

**2**

(b)     (*F* =)  =  = 10.6 N

*M1: Finding magnitude with a + sign.*

*A1F: Correct magnitude. Accept AWRT 10.63 and *

*Follow through incorrect answers to part (a).* M1A1F

**2**

(c)     (*a* =)  = 2.13 m s–2

*M1: Dividing their force from part (a) or magnitude by 5.*

*A1F: Correct acceleration.*

*Accept 2.12 (from truncation or 10.6 / 5) or  or
AWRT 2.13.*

*Follow through incorrect answers to parts (a) and (b).*

*Seeing just* ***a*** *= 1.4****i*** *+ 1.6****j*** *scores M1 A0* M1A1F

**2**

(d)     cos *α* =  or 

*M1: Trig equation to find the angle with: cos with 7 or 8
in the numerator and  in denominator*

OR

sin *α* =  or 

*sin with 7 or 8 in the numerator and  in denominator*

OR

tan *α* =  *tan with 7 and 8 in any position*

*A1F: Correct equation.* M1A1F

(*α* =)48.8°

*A1F: Correct angle. Accept 49° or AWRT 49°*

*Follow through incorrect answers to parts (a) and (b).*

A1F

**3**

**[9]**

**M2.**          (a)     900 × 0.8 = *T –* 800

*Three term equation of motion for the
caravan* M1

*Correct equation* A1

*T* = 720 + 800 = 1520 N

*Correct result from correct working; AG* A1

**3**

(b)     2400 × 0.8 = *F* − 400 − 800

*Four term equation of motion for the
combined body or car* M1

*Correct equation* A1

*F* = 1920 + 1200 = 3120 N

*Correct force* A1

**3**

**[6]**

 **M3.** (a)     5900 × 0.2 = 2500 – 800 – *R*

*M1: Equation of motion for tractor and trailer as a single
particle, with 2500, 800, R (which might be implied by
seeing 1180 and 1700 or 1180 and 3300) and 5900 × 0.2
OE, with any signs.*

*A1: Correct equation.* M1A1

(*R* = )2500 – 1180 – 800 = 520 N

*A1: Correct R.* A1

*If tension found first, do not award any marks until an
equation for R is obtained. Award M1 for
3500 × 0.2 = ±2500 ± R ± 1280.*

**3**

(b)     *T* – 800 = 2400 × 0.2

*M1: Equation for trailer with 2400 and 800.*

*A1: Correct equation.* M1A1

(*T* =)800 + 480 = 1280 N

*A1: Correct tension.* A1

**3**

**OR**

3500 × 0.2 = 2500 – 520 – *T*

*M1: Equation for tractor with 3500, 2500 and 520.*

*A1F: Correct equation.* (M1A1F)

(*T* =)2500 – 700 – 520 = 1280 N

*A1F: Correct tension.* (A1F)

**(3)**

*Follow through incorrect R from part (a).*

*If the tension has been found in part (a) it only needs to
be stated here.*

(c)     1280 N

*B1F: Same answer as part (b).*

*Do not accept – 1280.* B1F

**1**

**[7]**

**M4.**         (a)      (i)      *P* – 500 = 2200 × 0.8*P* = 1760 + 500

*M1: Equation of motion for car and caravan as a single body.Must see 2200 (or 1200 + 1000) multiplied by 0.8, and 500(or 200 + 300). Allow sign errors.*

*A1: Correct equation.* M1A1

         = 2260

*A1: Correct value for P.* A1

*(Award full marks for: (P =) 1760 + 500 = 2260 or similar to obtain correct final answer.)*

**OR** (If finding the tension first)

*P* – 1100 – 200 = 1200 × 0.8*P* = 960 + 1100 + 200

*M1: Equation of motion for car with their value for the tension.Must see 1200 multiplied by 0.8, 200 and their tension.*

*Allow sign errors.*

*A1: Correct equation.* (M1A1)

         = 2260

*A1: Correct value for P.* (A1)

*(Award full marks for: (P =) 960 + 200 + 1100 = 2260 or similar to obtain correct final answer.)*

**3**

(ii)      *T* – 300 = 1000 × 0.8*T* = 300 + 800

*M1: Equation of motion for caravan.*

*Must see 300 and 1000 multiplied by 0.8.*

*Allow sign errors.*

*A1: Correct equation.* M1A1

         = 1100

*A1: Correct tension. CAO* A1

**OR**

2260 – 200 – *T* = 1200 × 0.8*T* = 2260 – 200 – 960

*M1: Equation of motion for car. Must see 2260(or candidate’s P), 200 and 1200 multiplied by 0.8. Allow sign errors.*

*A1: Correct equation.* (M1A1)

         = 1100 N

*A1: Correct tension. CAO* (A1)

*If candidates find tension first it must be stated in part(a)(ii) to gain any marks.*

*The working does not have to be repeated if seen in part (a)(i).*

**3**

(b)     Resistance forces vary with speed (or velocity)**OR** Speed (or velocity) changes (or increases)

**OR** It accelerates

*B1: Correct explanation. Must not mention friction in main argument* B1

**1**

**[13]**

**M5 (**a)     (i)      3900 – 800 – *P =* 2000 × 1.3

*M1: Four term equation of motion for car
and trailer.* M1

*A1: Correct equation* A1

*P* = 3900 – 800 – 2600 = 500 N

*A1: Correct value for P* A1

**3**

(ii)     *T* − 500 = 600 × 1.3

*M1: Three term equation of motion for trailer.* M1

*A1: Correct equation* A1F

*T* = 500 + 780 = 1280 N

*A1: Correct tension* A1F

**3**

**[9]**