Summary Method M1 (Jan '13)

1.

a)

i.

Use an appropriate SUVAT equation with the given information about the first stage of motion to find the time.

ii.

Use an appropriate SUVAT equation with the given information about the first stage of motion to find the acceleration. You may use your value for time from part a)i., or you could use an alternative method.

b)

i.

Use an appropriate SUVAT equation with the given information about the second stage of motion. Note that the final speed from the first stage of motion can serve as your initial speed for the second stage.

ii.

Use an appropriate SUVAT equation for the second stage of motion, using information from b)i. if desired.

c)

Recall that average speed is calculated by finding the total distance travelled divided by the total time taken. Use information from previous parts of the question to find these two quantities.

2.

a)

Add the force vectors together. Since they are already in i and j form, it is necessary only to add the i components to find the i component of the resultant, and add the j components to find the j component of the resultant. Your answer should be in the form of a vector.

b)

Use Pythagoras' theorem to find the magnitude (size) of the vector found in part a).

c)

Use $F = ma$ to construct an equation involving the force and the mass to calculate acceleration. Since the question only requires the magnitude of acceleration, you may use the magnitude of the force as calculated in part b). Otherwise, using the vector form, finding the acceleration vector and then using Pythagoras to calculate its magnitude will yield the same result.

d)

Draw a diagram of the force, split into its component i and j parts. Use right angled trigonometry to determine the required angle.

3.

a)

Since the box has mass 3kg, a weight of $3g$ will be acting vertically down. Since it is resting on a slope, there will be a normal reaction (contact) force from the slope, acting upwards at right angles to the line of the slope. Since the surface is rough, friction will be acting in the opposite direction to motion (up the line of the slope).

b)

Resolve perpendicular to the slope (note: these forces are balanced since the box is not moving perpendicular to the slope) and solve to find R.

c)

Use $F_r = \mu R$ (we can use the equality since the box is in motion, meaning friction is at its maximum value).

d)

Resolve in the direction of motion (down the slope), and use $F = ma$. Note that a component of weight acts down the slope and friction acts directly up the slope.

e)

The assumptions made all need to concern the forces – there are no other forces acting on the box (eg no additional resistance forces such as air resistance). Alternatively, there is no turning effect on the box.

4.

a)

Draw a diagram of the two connected particles, including tension in the towbar acting inwards from both the tractor and the trailer. For the purposes of finding the resistive force R, the two can be considered to be one particle (thus eliminating the need to find the tension). Resolve in the direction of motion, making sure to correctly combine forwards and backwards forces, and use $F = ma$ (using the total mass of the two vehicles for m).

b)

Examine forces acting on the trailer. Resolve in the direction of motion and use $F = ma$ to determine the tension in the towbar.

c)

Note that the tension acting on the tractor is identical to the tension acting on the trailer, since it is the same towbar. The forces will both be acting in towards the centre of the towbar.

5.

Note that the question asks for two possible speeds. The description of the final speed of A does not include mention of the direction, so first calculate the speed of B assuming A continues in the same direction, then calculate its speed assuming A moves off in the opposite direction. Note that these will not simply be the negative of one another – momentum has direction, so while the speed and mass of A in each situation are unchanged, the change in direction means a different momentum. Find the momentum before the collision (recall that momentum is mv where m is the mass and v the velocity), and use the conservation of momentum principle to calculate the speed of B after the collision in the two different situations.

6.

a)

Construct a vector triangle, using the $3ms^{-1}$ and $4ms^{-1}$ as the component velocities, and determine the angle of the resultant velocity using right angled trigonometry.

b)

In order to return along the same path, the direction of the boat must be changed considerably so it not only cancels out the flow of the river but causes the boat to move in the opposite direction to this flow. Construct a vector triangle with the $3ms^{-1}$ as one of the component velocities, and the direction of the resultant velocity being in line with AB. The $4ms^{-1}$ will be the other component velocity, but at an unknown angle, so as to complete the triangle. Use a suitable non-right angled trigonometry rule to determine the magnitude of the resultant velocity.

7.

a)

Use SUVAT equations, involving the final velocity and the variable t for time. Note that the velocity will be a vector. It is not necessary to simplify your expression.

b)

Use a suitable SUVAT equation linking displacement (which will be a vector) to time. Note the initial position, since final position is a combination of initial position and displacement (adding the two vectors together).

c)

Use your expression for the velocity of the particle from part a), interpreting 'north-westerly direction' in terms of the i and j components of your vector, solve to find t, then substitute this value into your expression for position from part b). Note that a particle heading exactly north-west will have equal northerly and westerly components, and since i and j represent east and north respectively, this means the negative of the easterly component of the velocity must be equal to the northerly component.

8.

a)

Use the time given and the horizontal distance covered to calculate the horizontal component of velocity. Recall that, since there is no acceleration horizontally, $speed = \frac{distance}{time}$.

b)

Use SUVAT equations to deal with the vertical motion. You have information on time, acceleration and displacement, so you should be able to calculate initial velocity in the vertical direction. Construct a vector triangle using this vertical component of velocity and the horizontal component of velocity found in part a), and use this triangle to determine the magnitude of the resultant velocity. This is the speed of the particle, V.

c)

Resolving the initial velocity horizontally or vertically, construct an expression involving V, and either $\cos\alpha$ or $\sin\alpha$, equating to either the horizontal component of velocity from part a) or the vertical component from part b). Finally, solve to find α. Alternatively, use right-angled trigonometry on the vector triangle constructed in part b) to find the required angle α.