Checkpoints Chapter 2 FORCES

Question 27

B (ANS)
Once the ball has left the bat, there can be only two forces acting on it, the force due to gravity and the air resistance.
If the air resistance is defined as 'very little', then you can assume that this means zero.
$\therefore$ the only force acting is the weight force, which will act directly down.

Question 28

C (ANS)
Because the air resistance must oppose the motion, so it must be acting to the left. Now there are two forces acting.

Question 29

C (ANS)
The instant that the ball is in contact with the ground, the centre of mass of the ball is still moving forward, but the bottom of the ball (the part in contact with the ground) has a frictional force acting on it trying to slow it down. This force will act to the left, and since it is not acting at the CoM, it will produce a torque on the ball, giving rise to spin.

Question 30

The ball hits the ground with a speed given by:

$v^2 = u^2 + 2gx$

$\therefore v^2 = 0 + 2 \times 9.8 \times 2$

$\therefore v = 6.26$ m/s

If the ball was not to bounce, but just come to rest in 100 ms, i.e. 100×10^{-3} seconds, then the deceleration of the ball is

$$\frac{\Delta v}{\Delta t} = \frac{6.26}{100 \times 10^{-3}} = 62.6 \text{ N.}$$

This is much greater than the weight of 10N.

In this case we have assumed that the change in velocity was 6.26 m/s.
This is not true, as the ball will bounce back up, so the change in velocity would be closer to $6.26 \times 2 = 12.52$ m/s. This would make the force much greater.

We need the normal reaction force to be greater than the weight force, because the ball needs to experience a net force upwards, because this is the direction of the acceleration on the ball.

Question 31

A (ANS)
When a car is moving to the right, then to stop it a force needs to act to the left. The only force that stops cars (without deformation) is the friction between the tyre and the road. This friction must act to the left.
To accelerate a car, there needs to be a net force acting in the direction of the acceleration.
$\therefore$ this frictional force must act to the right.

Consider the 'hoon' doing burnouts in Lygon Street. They put oil on the road to minimise friction between the tyre and the road, the put their foot down on the accelerator and the wheels spin around, but the car does not go forward. When the oil is all burnt off, then the car shots forward, because of the frictional force of the road on the tyre.

Question 32

In a car accident, the car needs to come to rest from its initial speed. This means that it needs to lose momentum. This loss of momentum is given by Impulse = $F\,\Delta t = m\,\Delta v$. (Newton’s second law).

For a car of fixed mass, and a set speed, then the larger 't' is then the smaller 'F' is.

The crash barrier ‘crumples slowly’ so that the time of the collision is increased, and hence the average force ‘F’ is smaller. This smaller 'F' means that the average force exerted is less and so the damage done is less.

Question 33

C (ANS)
The car behind them accelerates them forwards. The seat exerts the force on John and Betty.

Question 34

The frictional force between the tyres and the road is the force that actually accelerates the car.

F = ma

∴ F = 1200 × 9

∴ F = 10800 N

∴ F = 1.1 × 10^4 N (ANS)

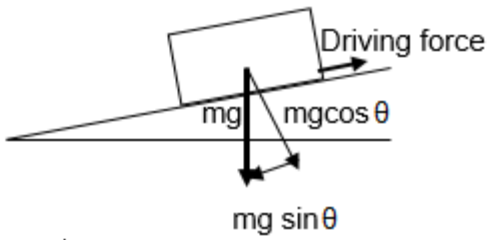
Question 35

The Normal reaction force = mg, because the car is not accelerating in the vertical direction.

$$\frac{1200 \times 9.0}{1200 \times 9.8} = \mathbf{0.92} \quad \textbf{(ANS)}$$

Question 36

If the train is travelling at a constant speed, then its acceleration is zero, which means that the sum of the forces acting on it is zero.
The driving force are overcoming the component of the train's weight force that is acting down the slope.

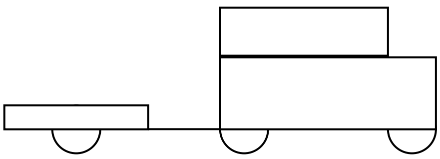


∴ mgsin θ = Driving force

= 600 × 10 × sin5^0

= 523 N (ANS)

Question 37



This is a simplified version of the diagram. Use your imagination to work out which is the car and which is the trailer.
If the tension in the 'coupling' (which is another word for the connecting rod between the car and the trailer) is 1000N, then this means that the net force acting on the trailer is 1000N. This is the force that is available to accelerate the trailer.
Since F = ma

∴ 1000 = m × 1

∴ m = 1000 kg. (ANS)

Question 38

If the mass of the car is 1500 kg, the driving force from the car needs to accelerate 1500 + 1000 kg, using F = ma

∴ F = 2500 × 1

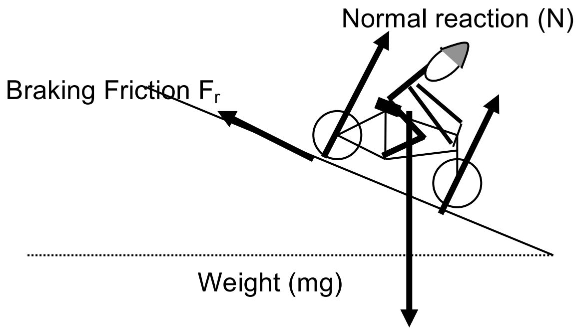
= 2500 N (ANS)

Question 39

The frictional force that the road is exerting on the driving wheels, is the only force acting (ignoring air resistance) and so it must be 2500N, because that is the size of the force that is causing the car/trailer combination to accelerate.

∴ 2500 N (ANS)

Question 40



The weight force should always come from the centre of mass of the system (Theo + bike)
In reality there are two normal reactions, they come from the bottom of the tyre, where it is in contact with the road. Often the idealised diagram only has one drawn on it.

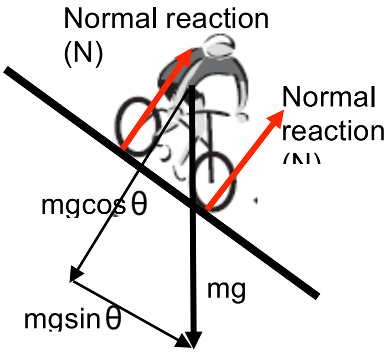
The braking force is the friction between the tyres and the road. In this diagram Theo only has the back brakes on. Note that Theo is wearing an approved helmet.

Question 41

The sum of the forces must be zero, because Theo does not accelerate down the hill.
This means that ΣF = ma

= 0 (ANS)

Question 42



The weight force can be resolved into 2 components

∴ mg cos θ = N

because the bike is not accelerating in this direction

∴ the unbalanced force causing the acceleration = mgsin θ

= $mg\sin 30^0$

= 0.5mg

∴ C (ANS)

Question 43

Theo feels the force that the ground pushes up on him, usually when he is vertical, this is the same as his weight force. (This is the force that he pushes down on the ground)

When he is accelerating down he is going to 'feel' the normal reaction force pushing on him. In this case the reaction force is given by mgcos θ .

This must always be less than mg, so Theo will feel '**lighter**'.

Question 44

This will only happen if we consider the effects of wind resistance. It is known that air resistance increases with speed, in fact air resistance $\propto v^3$. An Olympic class cyclist uses 90% of their energy overcoming air resistance when they are riding at 40km/hr. This is the reason why physicists, spend a lot of effort in trying to streamline the bike/rider combination. (This is yet another useless bit of trivia, but it continues to demonstrate the importance of physics in everyday life).

So, back to the question, the acceleration will decrease because the component of the weight force that is acting down the slope will stay constant, but the air resistance will increase.

Question 45

At time t = 2.5 s, there is a net force of 200N acting on her.

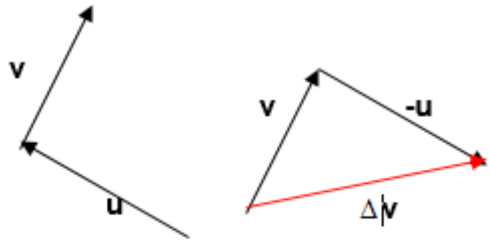
This means that since f = ma ∴ 200 = 80 × a

∴ a = 2.5 m/s^2. (ANS)

You need to be a little careful with this question because you must understand that even though the gradient of the line is zero, there is still a force acting, because this is a force v time graph, not a velocity v time graph.

Question 46

The direction of the change in velocity is given by the vector subtraction of **v - u**.



∴ C (ANS)

Question 47

The change in velocity is always given by **v**(final) – **v**(initial). This is a vector equation, and it turned out to be a 1:1:$\sqrt{2}$ triangle.

∴ 14.1 m/s (ANS)

Question 48

The impulse I = m Δ v

= 0.250 × 14.14

= 3.54 Ns (ANS)

Question 49

The impulse on the bat has to be the equal and opposite of the impulse on the ball.

∴ 3.5 Ns (ANS)

Question 50

She is travelling at a steady speed of 15 m/s. So she is not accelerating

∴ the sum of the forces is zero. **∴ 0 N (ANS)**

Question 51

For the sum of the forces to be zero, then the ground must be exerting a force equal to in size, but opposite in direction, to the frictional forces acting.
So the ground must be exerting a force of (55 + 5) = **60 N** **(ANS)**

Question 52

$u = 0$, $x = 16$, $t = 4$, $a = ??$

$x = ut + \frac{1}{2} a t^2$

$16 = 0 + \frac{1}{2} \times a \times 4^2$

$16 = 8a$

∴ **$a = 2$ m/s^2 (ANS)**

Question 53

$F = ma$

$\therefore F = 90 \times 2$
$= \mathbf{180\ N}$ **(ANS)**

Question 54

This is the force that is causing the bike to accelerate. ∴ **180 N** **(ANS)**

Question 55 **(2010 Q2, 2m, 90%)**

The weight of m_2 will cause both blocks to accelerate at the same rate.

Using $\Sigma F = (m_1 + m_2)a$
gives $0.1 \times 10 = (0.4 + 0.1)a$
$\therefore 1.0 = 0.5 \times a$
∴ **$a = 2$ m s^{-2} (ANS)**

Question 56 **(2010 Q8, 2m, 75%)**

Rebecca is correct.
Apparent weightlessness occurs when the Normal reaction is zero, true weightlessness is when $g = 0$.
The car is accelerating radially inwards such that
$mg - N = ma$ gives $N = 0$.
In this case they feel weightless, because $N = 0$, but they are not actually weightless.

To get full marks on this question you needed to make two statements,

1. Rebecca was correct
2. **WHY** she was correct.

Question 57 **(2010 Q13, 2m, 55%)**

When the spring has extended 0.40 m, the mass is in equilibrium.
$\therefore mg = k\Delta x$.
You must ALWAYS use Δx, to remind yourself that it is the extension of the spring, not the length of the spring that is used in calculations.
$\therefore 2.0 \times 10 = k \times 0.40$
∴ **$k = 50$ N m^{-1}** **(ANS)**

Question 58 **(2011 Q1, 1m, 91%)**

Use $\Sigma F = ma$
$\therefore \Sigma F = (500 + 2000) \times 0.5$
∴ **$\Sigma F = 1250$ N** **(ANS)** (Note, this is a very light tractor pulling a very heavy trailer)

Question 59 **(2011 Q2, 2m, 55%)**

The only force that we need to consider that is acting on the trailer is the tension. Therefore $T = ma$
$\therefore T = 2000 \times 0.5$
∴ **$T = 1000$ N** **(ANS)**

Question 60 **(2011 Q3, 2m, 80%)**

Since the acceleration is constant, use an equation of motion.
$\therefore x = ut + \frac{1}{2}at^2$
Gives $x = 0.5 \times 0.5 \times 5^2$
∴ **$x = 6.25$ m** **(ANS)**

Question 61 **(2011 Q7, 2m, 55%)**

Use Newtons third law.
$\therefore F_{C\ on\ B} = -F_{B\ on\ C}$
The three forces acting on C are:
Its weight, mg
The normal reaction
The weight of A and B.
$\therefore F_{B\ on\ C} = (0.050 + 0.10) \times 10$
$\therefore F_{B\ on\ C} = 1.5$ N
∴ **$F_{C\ on\ B} = 1.5$ N (upwards)** **(ANS)**

Question 62 **(2011 Q8, 2m, 50%)**

The blocks will be in free fall, so their acceleration will be g.
$\therefore F_{B\ on\ C} = 0$, because they are both in free fall, and accelerating at the same rate.
∴ **$F_{B\ on\ C} = 0$** **(ANS)**

Question 63 (2012 Q3, 2m, 70%)

Force is a vector, so the magnitude of the force and the direction of the force need to be taken into consideration.
A, C and D will all have a net force in the vertical direction. B is the only option that would allow the vectors to sum to zero.

∴ **B (ANS)**

Question 64 (2012 Q4a, 2m, 75%)

Cable A is supporting both masses.
The net force on the 2.0 kg sphere is zero.
Therefore the tension in cable A is equal and opposite to the weight of both spheres.

∴ T = (1.0 + 2.0) × 10

∴ **T = 30 N (ANS)**

The direction of this force is **UP.**

Question 65 (2012 Q4b, 2m, 15%)

Newton's third law can be written in the form;

$\mathbf{F}_{A\text{ on }B} = -\mathbf{F}_{B\text{ on }A}$

Then the weight of sphere is

$F_{\text{Earth on Sphere}}$

In terms of Newton's action and reaction pairs, the 'reaction' will be

$\mathbf{F}_{\textbf{Sphere on Earth}}$ **UP (ANS)**

This question was done very poorly, 15%, so ensure that you understand the concepts underlying the answer.

Question 66 (2012 Q5a, 1m, 60%)

Constant speed implies that the net force is zero.

∴ T_2 = 400 N and

∴ $T_1 = 400 + T_2$

∴ **T_1 = 800 N (ANS)**

Question 67 (2012 Q5b, 2m, 60%)

Isolate the second log.

∴ ΣF = ma

∴ $T_2 - 400 = 600 \times 0.50$

∴ $T_2 = 300 + 400$

∴ **T_2 = 700 N (ANS)**

Question 68 (2012 Q5c, 2m, 80%)

U = 4.0, a = 0.50, x = 20, v = ?

Use $v^2 - u^2 = 2ax$

∴ $v^2 - 4^2 = 2 \times 0.5 \times 20$

∴ $v^2 = 20 + 16$

∴ $v^2 = 36$

∴ **v = 6 m/s (ANS)**

Question 69 (2012 Q5d, 3m, 53%)

Rope 1 needs to provide the tension to accelerate both logs, so the tension in it will be greater than that of Rope 2.

∴ **Rope 1 (ANS)**

Use ΣF = ma

∴ $T_1 - T_2 - 400 = 600a$

and

$T_2 - 400 = 600a$

∴ $T_2 = 600a + 400$

∴ $T_1 - (600a + 400) - 400 = 600a$

∴ $T_1 = 600a + (600a + 400) + 400$

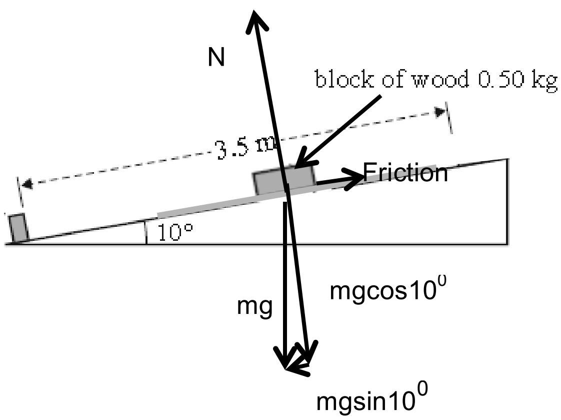
Use T_1 = 2400 N at its breaking point.

∴ 2400 = 1200a + 800

∴ 1600 = 1200 × a

∴ **a = 1.33 ms^{-2} (ANS)**

Question 70 (2013 Q1b, 3m, 40%)



From the diagram we get

ΣF = ma

∴ 0.5a = mgsin10^0 – Friction

Need to find 'a'.

Use $x = ut + ½at^2$ to get

3.5 = ½ × a × 6^2

∴ a = 0.1944

∴ 0.5 × 0.1944 = 0.5 × 10 × sin10^0 – Friction

∴ 0.0972 = 0.8682 – Friction

∴ **Friction = 0.77 N (ANS)**

Note that the answer in the back of the book is incorrect.

Question 71 (2013 Q2a, 1m, 70%)

W = mg
∴ W = 2 × 10
= 20 N (ANS) Make sure you answer the question, by including the unit.

Question 72 (2013 Q2b, 3m, 27%)

Use the equations $m_1a = m_1g - T$
and $T = m_2a$
∴ 2a = 20 – 6a
∴ 8a = 20
∴ a = 2.5 ms^{-2}
Substitute into $T = m_2a$
∴ T = 6 × 2.5
= 15 N (ANS)
Note that this question was done very poorly on the exam.

Question 73 (2014 Q1b, 2m, 50%)

Use T = ∑ma
= 2 × 10 × 10^3 × 0.2
= 4 × 10^3 N (ANS)

Question 74 (2014 Q2a, 2m, 60%)

Use the equation F = k × Δx
F = mg, so
0.05 × 10 = k × 0.1
∴ 0.5 / 0.1 = k
∴ k = 5 N m^{-1}

0.1 × 10 = k × 0.2
∴ 0.1 / 0.2 = k
∴ k = 5 N m^{-1}

0.15 × 10 = k × 0.3
∴ 0.15 / 0.3 = k
∴ k = 5 N m^{-1}

∴ k = 5 N m^{-1} (ANS)
