Student name: ________________________________ Class: ____________

Sydney Boys High School

Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample:	2 + 4 =	(A) 2	(B) 6	(C) 8	(D) 9
		A ○	B ●	C ○	D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ☒ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

correct

A ☒ B ☒ C ○ D ○

Start Here ➔

1.	A○	B○	C○	D○	**11.**	A○	B○	C○	D○
2.	A○	B○	C○	D○	**12.**	A○	B○	C○	D○
3.	A○	B○	C○	D○	**13.**	A○	B○	C○	D○
4.	A○	B○	C○	D○	**14.**	A○	B○	C○	D○
5.	A○	B○	C○	D○	**15.**	A○	B○	C○	D○
6.	A○	B○	C○	D○	**16.**	A○	B○	C○	D○
7.	A○	B○	C○	D○	**17.**	A○	B○	C○	D○
8.	A○	B○	C○	D○	**18.**	A○	B○	C○	D○
9.	A○	B○	C○	D○	**19.**	A○	B○	C○	D○
10.	A○	B○	C○	D○	**20.**	A○	B○	C○	D○

Student name: ________________________________ Class: ____________

Sydney Boys High School

Year 11 Physics

June 2019

Half-Yearly Cohort Assessment
Kinematics and Dynamics

General Instructions

- Reading time: 5 minutes
- Working time: 75 minutes
- Write using black or blue pen
- Draw diagrams using pencil
- SHOW ALL WORKING
- Board approved calculators may be used
- A data sheet, formula sheets and Periodic Table are provided at the back of this paper
- Write your name in ALL spaces provided

Total marks – 55

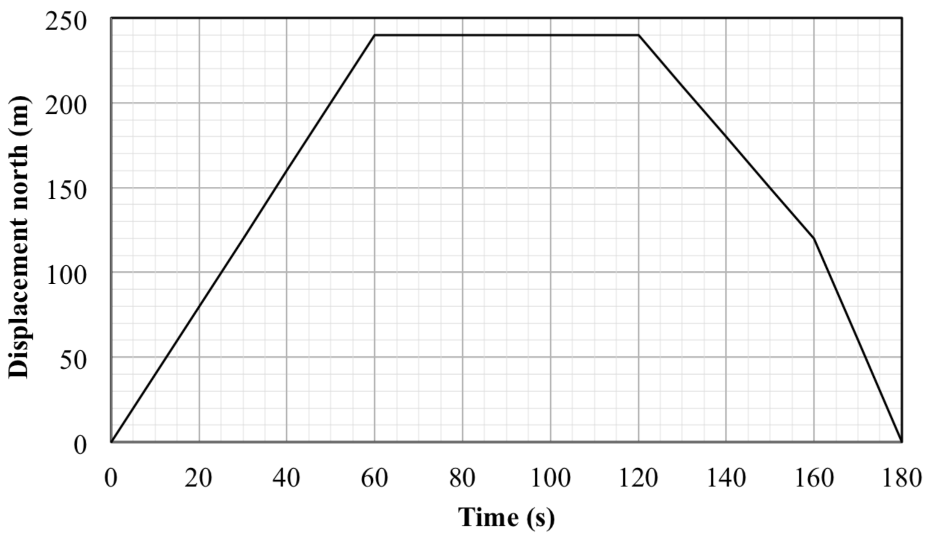
Part A – Multiple Choice
- 20 marks

Part B – Free Response
- 35 marks

PART A – Multiple Choice (20 marks)

Questions 1−3 Use the information below.

A car's displacement was measured as it drove along a race track. The results are shown in the graph below.



1. In which time interval is the car's speed greatest?

(A) 0−60 seconds
(B) 60−120 seconds
(C) 120−160 seconds
(D) 160−180 seconds

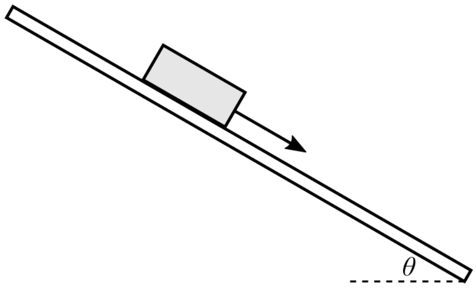
2. What is the car's average speed over the 180 seconds?

(A) 0 m s^{-1}
(B) 1.3 m s^{-1}
(C) 2.7 m s^{-1}
(D) 3.6 m s^{-1}

3. What is the car's average velocity over the 180 seconds?

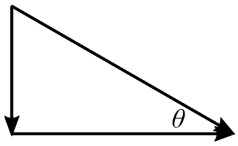
(A) 0 m s^{-1} north
(B) 1.3 m s^{-1} north
(C) 2.7 m s^{-1} north
(D) 3.6 m s^{-1} north

4. A brick is placed on a wooden plank. The plank is tilted until the brick slides down the wooden plank at a constant speed, as shown below.

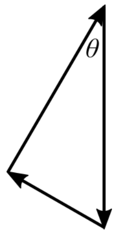


Which diagram best represents the forces (not shown on the diagram) acting on the brick?

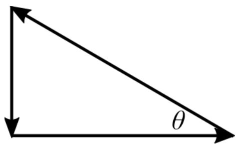
(A)



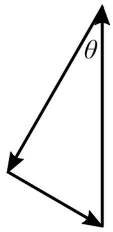
(B)



(C)



(D)



5. An astronaut weighs 845 N on Earth. On the moon (with a gravitational field strength of 1.62 m s^{-2}), his weight will be:

(A) 140 N
(B) 845 N
(C) 1369 N
(D) 5711 N

6. In inelastic collisions:

	Momentum is	*Kinetic energy is*	*Total energy is*
(A)	not conserved	not conserved	not conserved
(B)	not conserved	conserved	not conserved
(C)	conserved	conserved	conserved
(D)	conserved	not conserved	conserved

7. During a trip to Mars, a space probe's booster rocket is fired, doubling the speed and halving the mass of the probe. If the space probe originally had a kinetic energy of K and a momentum of p, which of the following choices show the correct values after the booster rocket has been fired?

	Kinetic energy	*Momentum*
(A)	K	p
(B)	$2K$	p
(C)	$2K$	$2p$
(D)	$4K$	$2p$

8. A horse walks 2.6 km north in 20 minutes, then turns right and trots east 3.8 km in 10 minutes. The average speed and average velocity are:

	Average speed ($m\ s^{-1}$)	*Average velocity* ($m\ s^{-1}$)
(A)	6.4	4.6 N56°E
(B)	9.2	9.2 E
(C)	12.8	9.2 N56°E
(D)	12.8	12.8 N56°E

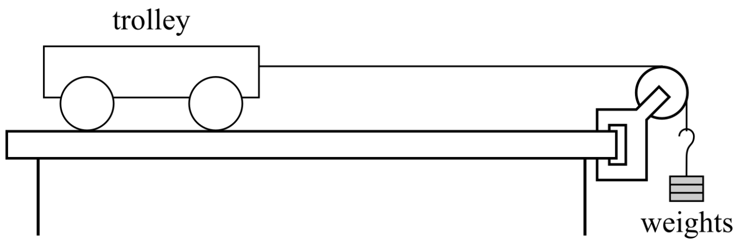
9. The women's world record for the 100 m race is 10.49 s, held by Florence Griffith-Joyner. Assuming that she has a constant acceleration for the entire race, what is her acceleration?

(A) 0.9 m s^{-2}
(B) 1.8 m s^{-2}
(C) 4.9 m s^{-2}
(D) 9.5 m s^{-2}

10. An apple is placed on a desk. The apple does not fall, due to the reaction force of the desk on the apple. What is the action force, according to Newton's 3rd Law?

(A) The downwards force of the apple acting on the desk.
(B) The downwards force of the desk on the ground.
(C) The gravitational force of the Earth acting on the apple.
(D) The gravitational force of the apple acting on the Earth.

11. A 1.6 kg trolley is tied to a 450 g mass that hangs over a pulley, as shown below. Ignoring friction, what is the acceleration of the trolley across the bench?



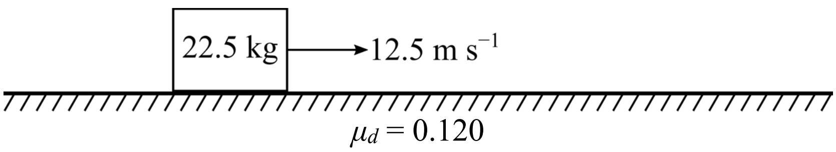
(A) 0.00 m s^{-2}
(B) 0.28 m s^{-2}
(C) 2.15 m s^{-2}
(D) 2.75 m s^{-2}

12. A hot air balloon floats motionless at an altitude of 2.5 km.

At this point in time, it would be correct to say that:

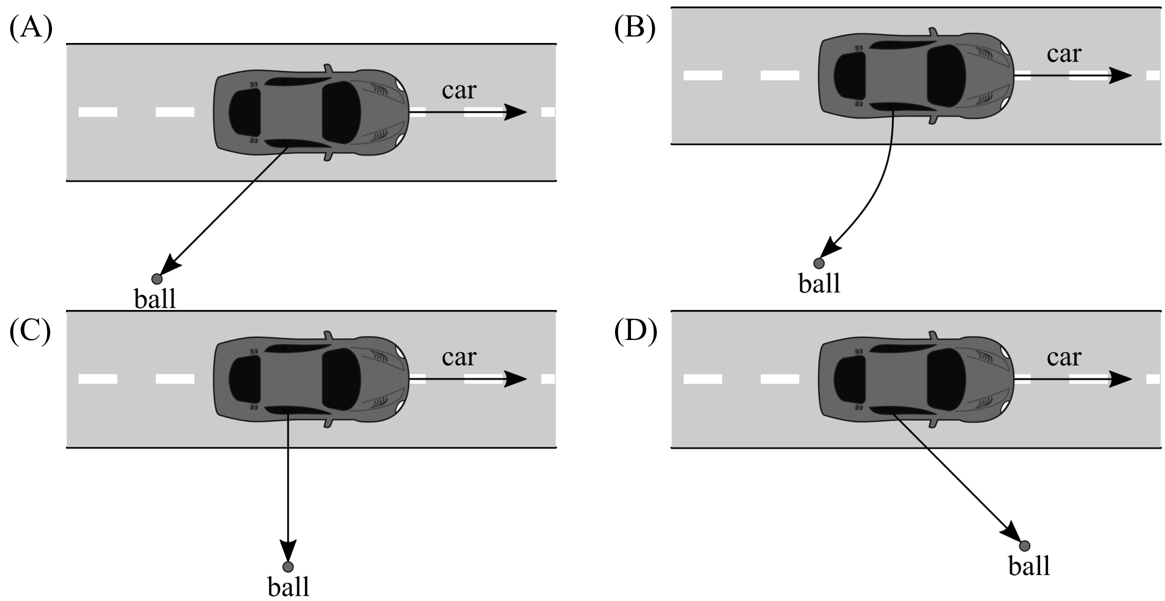
(A) the hot air balloon has become weightless.
(B) the hot air balloon's lift is greater than it weight.
(C) there are no forces acting on the hot air balloon.
(D) the net force on the hot air balloon is zero.

13. A box is pulled along the floor with a dynamic coefficient of friction of 0.120 at a speed of 12.5 m s^{-1}. What is the pulling force being applied to the box to maintain this speed?



(A) 0 N
(B) 26.5 N
(C) 221 N
(D) 281 N

14. A ball is thrown out of the passenger window of a car moving to the right (ignore air resistance). If the ball is thrown out perpendicular to the velocity of the car, which of the following best depicts the path the ball takes, as viewed from a stationary observer above?



15. On Christmas eve, Santa had just finished his last toy delivery when he almost collided with a fighter jet on patrol. If Santa was flying at 145 m s^{-1} due north and the jet was flying at 270 m s^{-1} due east, what was the velocity Santa relative to the fighter jet?

(A) 125 m s^{-1} NE
(B) 125 m s^{-1} N62°W
(C) 306 m s^{-1} N62°E
(D) 306 m s^{-1} N28°W

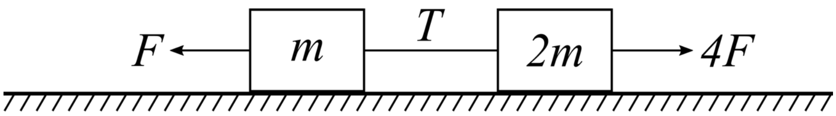
16. Which of Newton's laws best explains why motorists should wear a seatbelt?

(A) Newton's 1st Law
(B) Newton's 2nd Law
(C) Newton's 3rd Law
(D) Newton's Law of Gravitation

17. A juggler throws a ball into the air with an initial speed of v so that it reaches a maximum height at time t. If the juggler throws the next ball with an initial speed of $2v$, the second ball with reach a maximum height at time:

(A) t
(B) $\sqrt{2}t$
(C) $2t$
(D) $4t$

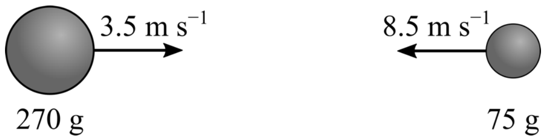
18. Two blocks of masses m and $2m$, connected by a light, inextensible string are resting on a frictionless horizontal surface. Opposing forces F and $4F$ are applied to each side of the connected blocks, as shown below.



What is the tension, T, in the string between the two blocks?

(A) F
(B) $2F$
(C) $3F$
(D) $5F$

19. The initial conditions of two balls are shown below before they collide.



If the 270 g ball rebounds at 1.72 m s^{-1} after the collision, what is the final speed of the 75 g ball?

(A) 2.1 m s^{-1}
(B) 7.1 m s^{-1}
(C) 10.3 m s^{-1}
(D) 14.9 m s^{-1}

20. A force is applied to a 12.5 kg block along a smooth, frictionless surface so that it increases its speed from 5.5 m s^{-1} to 18.4 m s^{-1} in 7 seconds. What is the work done by the force?

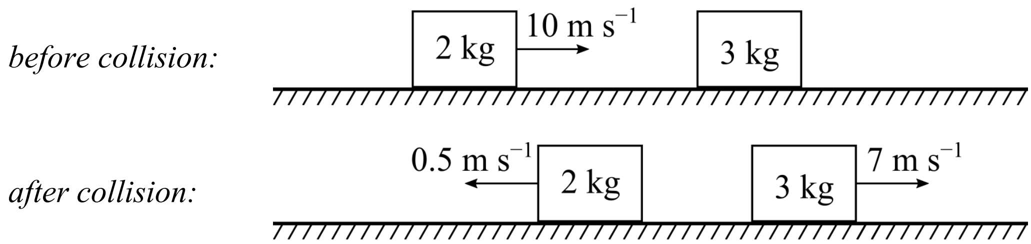
(A) 39 J
(B) 424 J
(C) 845 J
(D) 1927 J

PART B – Free Response (35 marks)

Marks

Question 21 (3 marks)

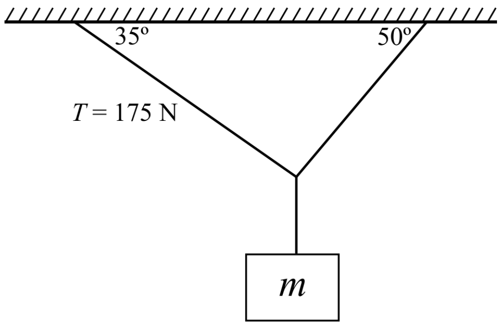
Two blocks interact on a smooth, frictionless surface. The motion of the two blocks are shown below.



Identify whether the interaction of the blocks is a valid elastic or inelastic collision. Justify your answer. **3**

Question 22 (2 marks)

A block of unknown mass hangs motionless on two strings suspended from a ceiling, as shown below. The tension in the left-hand string is 175 N.



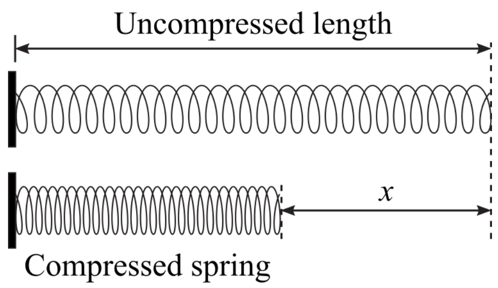
Calculate the mass of the block. **2**

Question 23 (7 marks)

The elastic potential energy stored by a spring when it is compressed is given by:

$$U_{elastic} = \frac{1}{2}kx^2$$

where k is the spring constant and x is the distance the spring is compressed.



A 0.500 kg ball is placed on top of the end of a vertical spring with a spring constant of 425 N m^{-1}.

(a) How much does the spring compress when the ball comes to rest? **2**

(b) The ball is then pressed down to a total compression of the spring of 0.150 m. When the ball is released, it is launched into the air. Calculate the launch speed of the ball. **3**

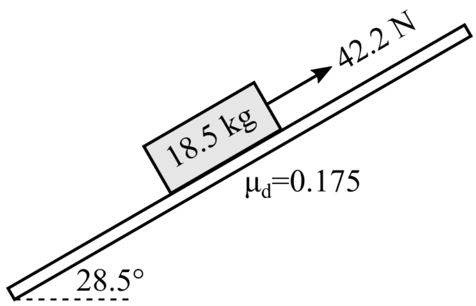
(c) Calculate the maximum height that the ball reaches above the launch point. **2**

Question 24 (3 marks)

A laboratory created a new type of rubber compound. The compound is shaped into a ball and tested to see how well it bounces. The ball is observed to hold its shape very well, but it only bounces to half of its drop height. The rubber ball was also found to be warmer after the bounce. Mr Kay suggests that the compound could be used to coat his golf clubs to improve his driving range. With reference to the conservations laws involved, assess the validity of this suggestion. **3**

Question 25 (3 marks)

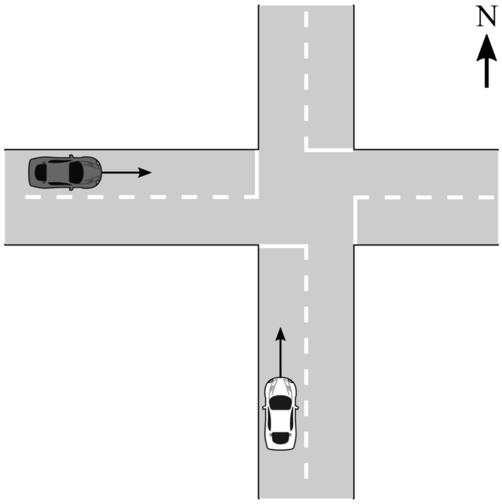
A block of mass 18.5 kg is pulled up a slope of 28.5° by a force of 42.2 N, as shown in the figure below. The dynamic friction between the block and the block is 0.175.



Calculate the acceleration of the block. **3**

Question 26 (5 marks)

Two cars are approaching an intersection, as shown below. The white car has a mass of 1750 kg and is driving north at 60 km h^{-1}. The grey car has a mass of 1450 kg and is driving east at 90 km h^{-1}.



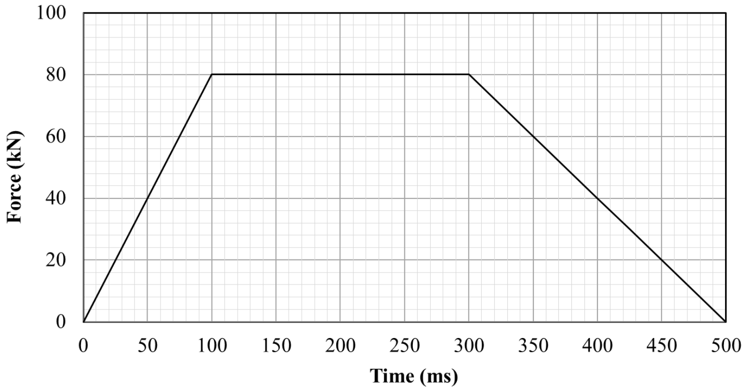
Unfortunately, neither car stops at the intersection and they collide, fusing together after the collision.

(a) Calculate the velocity of the fused cars immediately after the collision. **3**

(b) If the coefficient of friction between the tyres of the cars and the road is 0.75, calculate how far the fused cars will travel before stopping. **2**

Question 27 (4 marks)

During a crash test, a car of mass 1750 kg collides with a wall. Force sensors on the wall measure the force applied to the wall during the collision. A force-time graph is shown below for one of the collisions.



(a) Calculate the maximum deceleration of the car during the collision? **2**

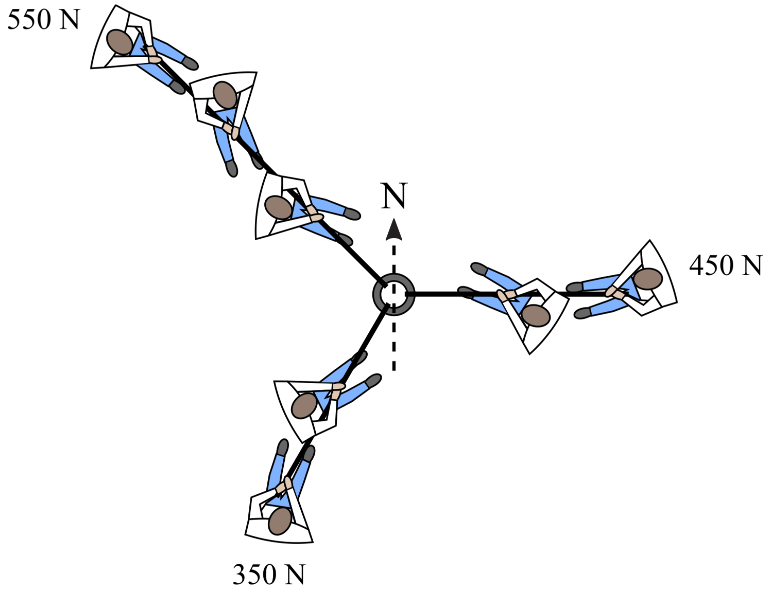
(b) Calculate the speed of the car before collision. **2**

Question 28 (2 marks)

A package is resting on an electronic balance inside a stationary cargo elevator. The balance reads 47.2 kg. The elevator starts moving between floors with a constant acceleration, and the balance now reads 32.8 kg. Calculate the acceleration of the elevator. **2**

Question 29 (4 marks)

A three-way tug-of-war is shown below, along with the forces being exerted by the three teams.



Use a scale vector diagram to determine the net force acting on the central ring and enter your result in the box below. The scale required for the vector diagram is provided. **4**

scale: 1 cm = 50 N

net force:

Question 30 (2 marks)

Bob's airplane can fly at 120 m s^{-1} in still conditions. In order to make an important delivery, he needs to fly to Fudgeton, which lies due north-east from his home town. During this trip, the plane is subjected to a constant cross-wind that blows to the west at 40 m s^{-1}. Determine the direction that he must orient his plane so that he can fly north-east, directly to Fudgeton. **2**

....

....

....

....

....

....

– **End of Paper –**

Student name: ______________________________ Class: ____________

Sydney Boys High School

Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ~~●~~ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

correct

A ~~●~~ B ~~●~~ C ○ D ○

○

Start Here ➔

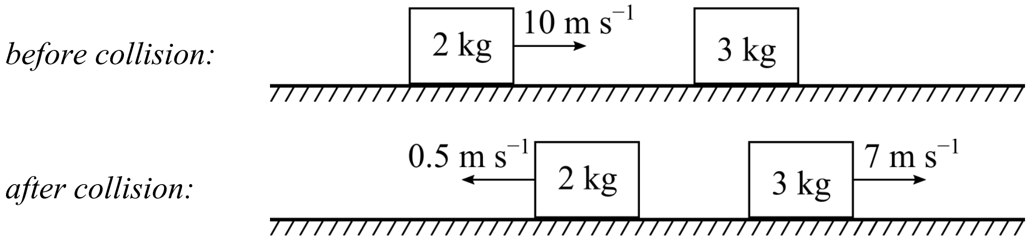
1.	A ○	B ○	C ○	D ●	**11.**	A ○	B ○	C ●	D ○
2.	A ○	B ○	C ●	D ○	**12.**	A ○	B ○	C ○	D ●
3.	A ●	B ○	C ○	D ○	**13.**	A ○	B ●	C ○	D ○
4.	A ○	B ●	C ○	D ○	**14.**	A ○	B ○	C ○	D ●
5.	A ●	B ○	C ○	D ○	**15.**	A ○	B ○	C ●	D ○
6.	A ○	B ○	C ○	D ●	**16.**	A ●	B ○	C ○	D ○
7.	A ○	B ●	C ○	D ○	**17.**	A ○	B ○	C ●	D ○
8.	A ○	B ○	C ●	D ○	**18.**	A ○	B ●	C ○	D ○
9.	A ○	B ●	C ○	D ○	**19.**	A ○	B ○	C ●	D ○
10.	A ●	B ○	C ○	D ○	**20.**	A ○	B ○	C ○	D ●

PART B – Free Response (35 marks)

Marks

Question 21 (3 marks)

Two blocks interact on a smooth, frictionless surface. The motion of the two blocks are shown below.



Identify whether the interaction of the blocks is a valid elastic or inelastic collision. Justify your answer. **3**

$\sum p_{before} = m_1 u_1 + m_2 u_2$ $\qquad$ $\sum p_{after} = m_1 v_1 + m_2 v_2$

$= 2 \times 10 + 3 \times 0 = 20 \text{ kg m s}^{-1}$ $\qquad$ $= 2 \times -0.5 + 3 \times 7 = 20 \text{ kg m s}^{-1}$

Momentum has been conserved, making it a *valid* collision.

$\sum K_{before} = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2$ $\qquad$ $\sum K_{after} = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$

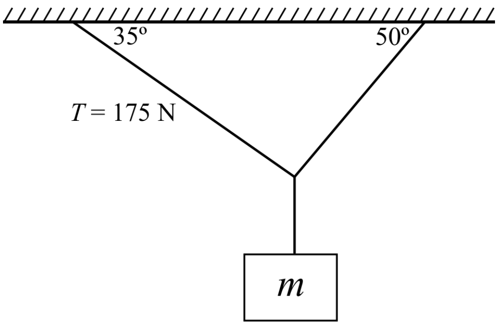
$= \frac{1}{2} \times 2 \times 10^2 + \frac{1}{2} \times 3 \times 0^2 = 100 \text{ J}$ $\qquad$ $= \frac{1}{2} \times 2 \times -0.5^2 + \frac{1}{2} \times 3 \times 7^2 = 73.75 \text{ J}$

Kinetic energy has not been conserved, making it a valid *inelastic* collision.

✓ correct values for momentum
✓ correct values for kinetic energy
✓ identifies collision as inelastic

Question 22 (2 marks)

A block of unknown mass hangs motionless on two strings suspended from a ceiling, as shown below. The tension in the left-hand string is 175 N.



Calculate the mass of the block. **2**

Equilibrium means that horizontal components of tensions in strings are equal:

$T_{left} \cos\theta_{left} = T_{right} \cos\theta_{right} \Rightarrow T_{right} = \dfrac{T_{left}\cos\theta_{left}}{\cos\theta_{right}} = \dfrac{175 \times \cos 35}{\cos 50} = 223 \text{ N}$

Equilibrium also means that vertical components of tensions balance weight of mass:

$T_{left} \sin\theta_{left} + T_{right} \sin\theta_{right} = mg \Rightarrow m = \dfrac{T_{left}\sin\theta_{left} + T_{right}\sin\theta_{right}}{g} = \dfrac{175 \sin 35 + 223 \sin 50}{9.8} = 27.7 = 28 \text{ kg}$

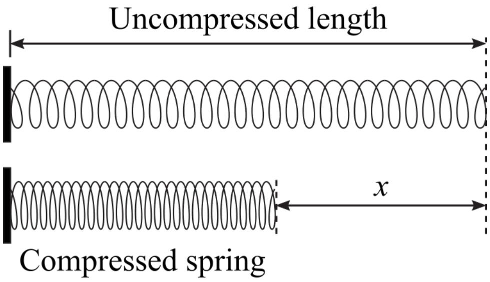
✓ correct value for T_{right}
✓ correct value, units & sig figs for *mass*

Question 23 (7 marks)

The elastic potential energy stored by a spring when it is compressed is given by:

$$U_{elastic} = \frac{1}{2}kx^2$$

where k is the spring constant and x is the distance the spring is compressed.



A 0.500 kg ball is placed on top of the end of a vertical spring with a spring constant of 425 N m^{-1}.

(a) How much does the spring compress when the ball comes to rest? **2**

Loss of gravitational potential energy transformed to elastic potential energy:

$$U_{elastic} = U_{gravitational}$$

$$\frac{1}{2}kx^2 = mgx \quad (\Delta h = x)$$

$$x = \frac{2mg}{k} = \frac{2 \times 0.500 \times 9.8}{425} = 0.0231 = 0.023 \text{ m} = 2.3 \text{ mm}$$

Note: Force ≠ Energy!!!!!!!!

✓ demonstrates $U_{elastic} = U_{gravitational}$
✓ correct value & units

(b) The ball is then pressed down to a total compression of the spring of 0.150 m. When the ball is released, it is launched into the air. Calculate the launch speed of the ball. **3**

Stored elastic potential energy transformed to kinetic energy & gravitational potential energy when it fully uncompresses:

$$U_{elastic} = U_{gravitational} + K$$

$$\frac{1}{2}kx^2 = mgx + \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{kx^2}{m} - 2gx} = \sqrt{\frac{425 \times .150^2}{0.500} - 2 \times 9.8 \times 0.150} = 4.023 = 4.0 \text{ m s}^{-1}$$

1 MARK: applies conservation of energy
~~2 MARKS: calculates $v = 4.36$ m s^{-1} with units~~
3 MARKS: correct value with units

(c) Calculate the maximum height that the ball reaches above the launch point. **2**

Stored elastic potential energy transformed to gravitational potential energy:

$$U_{elastic} = U_{gravitational}$$

$$\frac{1}{2}kx^2 = mg(x+s)$$

1 mark if answer = 0.98m or 1.13m

$$s = \frac{kx^2}{2mg} - x = \frac{425 \times 0.150^2}{2 \times 0.500 \times 9.8} - 0.150 = 0.826 = 0.83 \text{ m}$$

✓ uses appropriate equations with correct substitution
✓ correct value & units (no carry over)

Question 24 (3 marks)

A laboratory created a new type of rubber compound. The compound is shaped into a ball and tested to see how well it bounces. The ball is observed to hold its shape very well, but it only bounces to half of its drop height. The rubber ball was also found to be warmer after the bounce. Mr Kay suggests that the compound could be used to coat his golf clubs to improve his driving range. With reference to the conservations laws involved, assess the validity of this suggestion. **3**

* Mr Kay's suggestion is not valid, for the following reasons:

* the ball does not bounce well, indicating an inelastic collision (or the kinetic energy is not conserved)

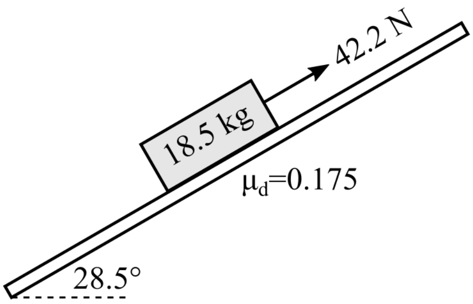
* the ball heated up during the test, indicating that the kinetic energy is transformed into thermal energy during collision with the ground (This is an energy transformation described by the Law of Conservation of Energy) (You could also say… * the ball held its shape, indicating that the kinetic energy was not transformed into mechanical deformation of the plastic)

Therefore, coating Mr Kay's golf club with the rubber will convert too much of the kinetic energy of the swinging golf club in to heat, rather than transferring it to the golf ball. As a result, the kinetic energy, and therefore, the speed of the golf ball with be reduced, making the suggestion invalid.

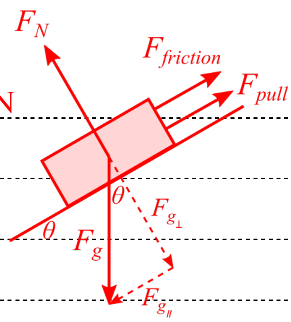
✓ correct and explicit judgement of validity i.e. suggestion is not valid
✓ applies conservation of energy to bounce stating that the bounce is not elastic and KE not conserved
✓ applies conservation of energy to the loss of KE through the conversion to heat.

Question 25 (3 marks)

A block of mass 18.5 kg is pulled up a slope of 28.5° by a force of 42.2 N, as shown in the figure below. The dynamic friction between the block and the block is 0.175.



Calculate the acceleration of the block. **3**



Force diagram shows $F_{g_{//}} = F_g \sin\theta = 18.5\times 9.8\times \sin 28.5 = 86.51$ N

Pulling force is less than gravitational force down slope, so block is sliding down slope, and friction will be acting up the slope:

$F_N = F_{g_\perp} = F_g \cos\theta = 18.5\times 9.8\times \cos 28.5 = 159.33$ N

$F_{friction} = \mu_d F_N = 0.175\times 159.33 = 27.88$ N

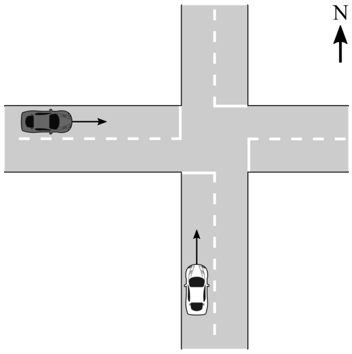
$F_{net} = F_{pull} + F_{friction} - F_{g_{//}} = 42.2 + 27.88 - 86.51 = -16.43 = 16.43$ N down slope

$F_{net} = ma \;\Rightarrow\; a = \frac{F_{net}}{m} = \frac{-16.43}{18.5} = -0.888 = 0.89$ m s^{-2} down slope

✓ uses correct EQUATION LINES for Normal Force and Friction
✓ correctly calculates $F_{friction}$ or Normal Force
✓ correct value, units & direction

Question 26 (5 marks)

Two cars are approaching an intersection, as shown below. The white car has a mass of 1750 kg and is driving north at 60 km h^{-1}. The grey car has a mass of 1450 kg and is driving east at 90 km h^{-1}.



Unfortunately, neither car stops at the intersection and they collide, fusing together after the collision.

(a) Calculate the velocity of the fused cars immediately after the collision. **3**

white car: $u_w = 60 \times \dfrac{1000}{60 \times 60} = 16.67$ m s^{-1} grey car: $u_g = 90 \times \dfrac{1000}{60 \times 60} = 25$ m s^{-1}

White car $p_{before} = m_w u_w = 1750 \times 16.67 = 29172.5$ kg m s^{-1} north

Grey car $p_{before} = m_g u_g = 1450 \times 25 = 36250$ kg m s^{-1} east

Fused cars will have: $p_{net} = \sqrt{p_{north}^2 + p_{east}^2} = \sqrt{29172.5^2 + 36250^2} = 46530.6$ kg m s^{-1}

$$v_{net} = \frac{p_{net}}{m_w + m_g} = \frac{46530.6}{1750 + 1450} = 14.54 \text{ m s}^{-1}$$

$$\theta_{bearing} = \tan^{-1}\left(\frac{p_{east}}{p_{north}}\right) = \tan^{-1}\left(\frac{36250}{29172.5}\right) = 51.17°$$

The velocity of the fused cars is 14.5 m s^{-1} (52 km/h) at N51°E

✓ Shows and correctly applies momentum EQUATION LINES
✓ correct speed of fused cars
✓ correct direction of fused cars

(b) If the coefficient of friction between the tyres of the cars and the road is 0.75, calculate how far the fused cars will travel before stopping. **2**

$F_{friction} = \mu F_N = 0.75 \times (1750 + 1450) \times 9.8 = 23520$ N

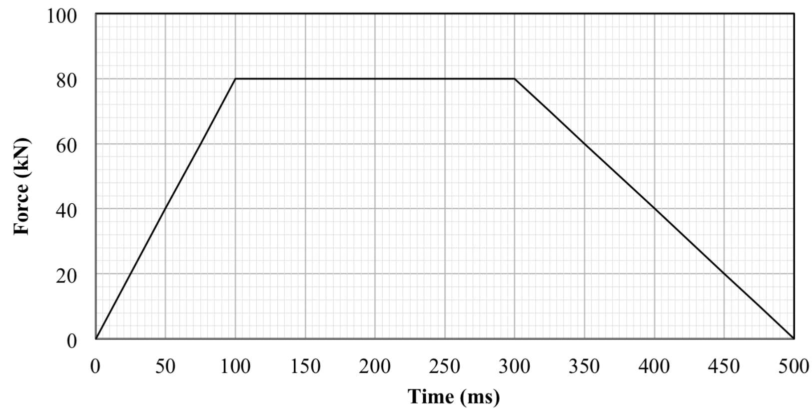
$K = \dfrac{1}{2}mv^2 = \dfrac{1}{2} \times (1750 + 1450) \times 14.54^2 = 338259$ J

$W = F_{friction} s = \Delta K \quad \Rightarrow \quad s = \dfrac{\Delta K}{F_{friction}} = \dfrac{338259}{23520} = 14.38 = 14$ m

✓ correct $F_{friction}$ EQUATION LINE and correct friction calculation
✓ correct distance with units

Question 27 (4 marks)

During a crash test, a car of mass 1750 kg collides with a wall. Force sensors on the wall measure the force applied to the wall during the collision. A force-time graph is shown below for one of the collisions.



(a) Calculate the maximum deceleration of the car during the collision? **2**

Maximum acceleration occurs when there is maximum force (from 100–300 ms):

$F_{max} = ma_{max} \quad \Rightarrow \quad a_{max} = \dfrac{F_{max}}{m} = \dfrac{80\times10^3}{1750} = 45.7 \text{ m s}^{-2}$

✓ correct section of graph used
✓ correct equation & substitution

(b) Calculate the speed of the car before collision. **2**

Impulse is equal to area under the curve:

$J = \dfrac{1}{2}\times100\times10^{-3}\times80\times10^3 + 200\times10^{-3}\times80\times10^3 + \dfrac{1}{2}\times200\times10^{-3}\times80\times10^3$

$= 28000 \text{ kg m s}^{-1}$

$J = \Delta p = m\Delta v \quad \Rightarrow \quad \Delta v = \dfrac{J}{m} = \dfrac{28000}{1750} = 16 \text{ m s}^{-1}$

✓ correct area under curve
✓ correct equation & substitution

Question 28 (2 marks)

A package is resting on an electronic balance inside a stationary cargo elevator. The balance reads 47.2 kg. The elevator starts moving between floors with a constant acceleration, and the balance now reads 32.8 kg. Calculate the acceleration of the elevator. **2**

Force on balance when stationary: $F_{stationary} = F_g = mg = 47.2\times9.8 = 462.56 \text{ N}$

Force on balance when accelerating: $F_{moving} = "F_g" = "m"g = 32.8\times9.8 = 321.44 \text{ N}$

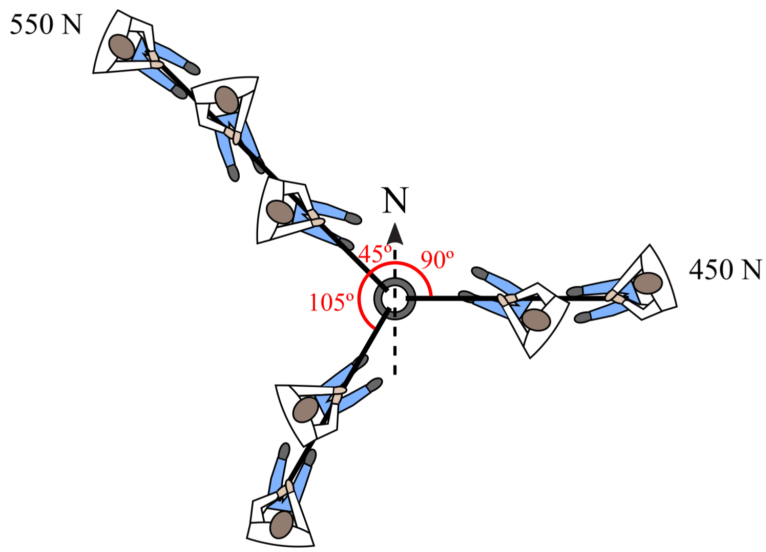
Difference due to motion of elevator: $F_{accel} = F_{moving} - F_{stationary} = 321.4 - 462.6 = -141.12 \text{ N}$

$F_{accel} = ma \quad \Rightarrow \quad a = \dfrac{F_{accel}}{m} = \dfrac{-141.12}{47.2} = -2.99 = 3.0 \text{ m s}^{-2}$ down

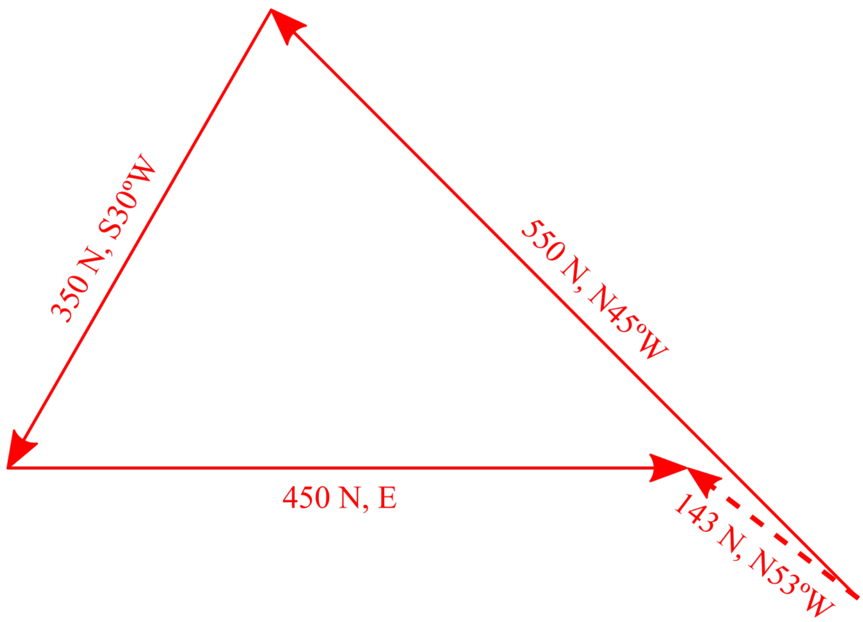
✓ correct value, units & sig figs
✓ correct direction

Question 29 (4 marks)

A three-way tug-of-war is shown below, along with the forces being exerted by the three teams.



Use a scale vector diagram to determine the net force acting on the central ring and enter your result in the box below. The scale required for the vector diagram is provided. **4**



scale: 1 cm = 50 N

net force: 143 N, N53°W

✓ three force vectors
✓ head-to-tail addition
✓ three correct lengths
✓ correct net force (±10 N, ±2°)

Question 30 (2 marks)

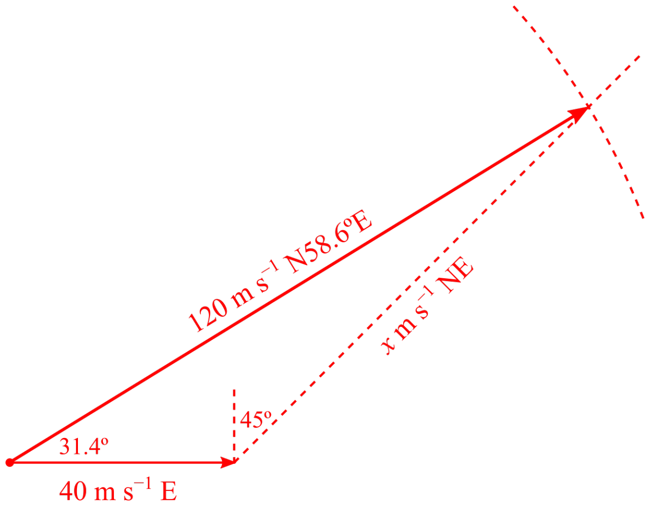
Bob's airplane can fly at 120 m s^{-1} in still conditions. In order to make an important delivery, he needs to fly to Fudgeton, which lies due north-east from his home town. During this trip, the plane is subjected to a constant cross-wind that blows to the west at 40 m s^{-1}. Determine the direction that he must orient his plane so that he can fly north-east, directly to Fudgeton. **2**

$v_{plane,wind} = v_{plane} - v_{wind} = x \text{ m s}^{-1} \text{ NE} - 40 \text{ m s}^{-1} \text{ W} = x \text{ m s}^{-1} \text{ NE} + 40 \text{ m s}^{-1} \text{ E}$

$= 40 \text{ m s}^{-1} \text{ E} + x \text{ m s}^{-1} \text{ NE}$

Start by drawing a vector 40 m s^{-1} E (say 4 cm), then draw a long line NE from the head of the 40 m s^{-1} E vector (speed of plane with respect to ground is unknown). Using a ruler, place 0 of ruler on start of 40 m s^{-1} E vector and swing ruler to find point on NE line that is 120 m s^{-1} away (that is, 12 cm away). Draw a line and measure direction.

$\Rightarrow$ Plane must fly at an orientation of N58.6°E.



OR

From Pythagoras:

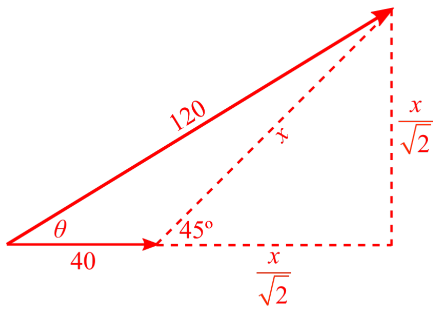
$$\left(\frac{x}{\sqrt{2}}\right)^2 + \left(40 + \frac{x}{\sqrt{2}}\right)^2 = 120^2$$

$$x^2 + \frac{80}{\sqrt{2}}x - 12800 = 0$$

This gives quadratic solutions of -144.9033 & <u>88.3347</u>

$$\Rightarrow \frac{x}{\sqrt{2}} = \frac{88.3347}{\sqrt{2}} = 62.462$$

$$\text{and } \theta = \sin^{-1}\left(\frac{62.462}{120}\right) = 31.4°$$



✓ demonstration of relative motion equation
✓ correct direction (±1°)

– **End of Paper** –