L6th

A level Physics

Easter Vacation Work

<u>Forces, Moments, Newton's Laws,</u>

<u>Collisions and Work Done</u>

<u>How much work should you be doing over the 3 weeks that you have off?</u>

- 2 hours of file tidying – get them perfectly ordered
- 1 hour for each teacher of consolidating notes – are you missing any flashcards etc?
- *2 -3 hours answering these questions*

<u>What we are expecting to check when you return:</u>

✔ These questions have been marked

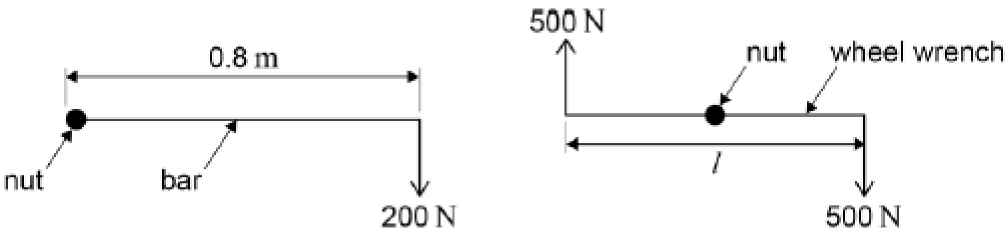
✔ You have calculated your percentage and grade

✔ Written down the areas where you are still struggling. We will collate these and swiftly address these in clinic during the first few weeks of term.

Total: / 134 marks	**Grade (circle):**
Topics that you are still struggling with and why:	**A* = 75%**
	A = 70%
	B = 65 %
	C = 60 %

Happy Easter!

Q1. A car wheel nut can be loosened by applying a force of 200 N on the end of a bar of length 0.8 m as in **X**. A car mechanic is capable of applying forces of 500 N simultaneously in opposite directions on the ends of a wheel wrench as in **Y**.



X **Y**

What is the minimum length l of the wrench which would be needed for him to loosen the nut?

A 0.16 m

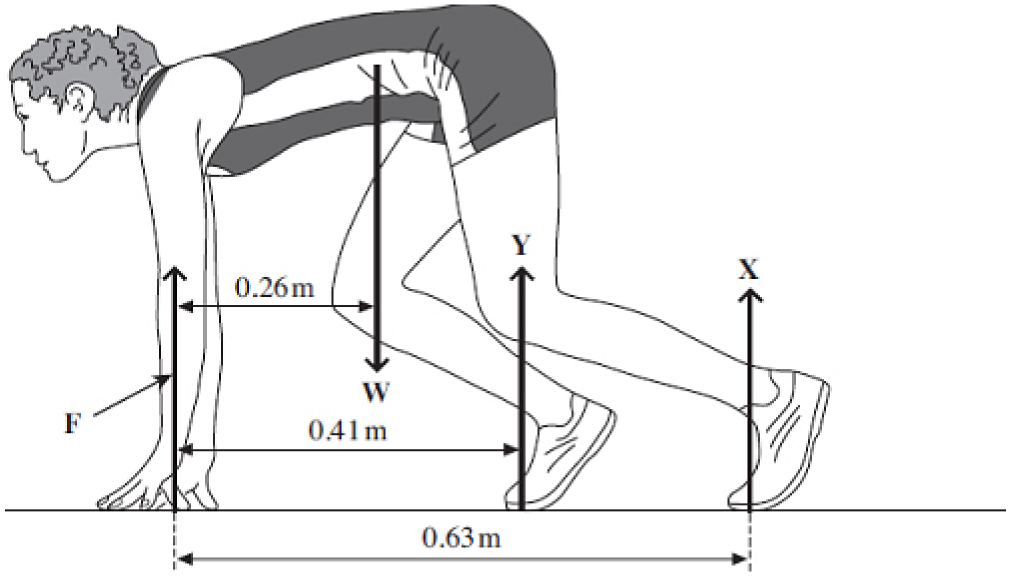
B 0.32 m

C 0.48 m

D 0.64 m

(Total 1 mark)

Q2. A sprinter is shown before a race, stationary in the 'set' position, as shown in the figure below. Force **F** is the resultant force on the sprinter's finger tips. The reaction force, **Y**, on her forward foot is 180 N and her weight, **W**, is 520 N. **X** is the vertical reaction force on her back foot.



(a) (i) Calculate the moment of the sprinter's weight, **W**, about her finger tips. Give an appropriate unit.

answer = ... unit ....

(2)

(ii) By taking moments about her finger tips, calculate the force on her back foot,marked **X**.

answer = ...N

(3)

(iii) Calculate the force **F**.

answer = ...N

(1)

(b) The sprinter starts running and reaches a horizontal velocity of 9.3 ms^{-1} in a distance of 35 m.

(i) Calculate her average acceleration over this distance.

answer = ...m s^{-2}

(2)

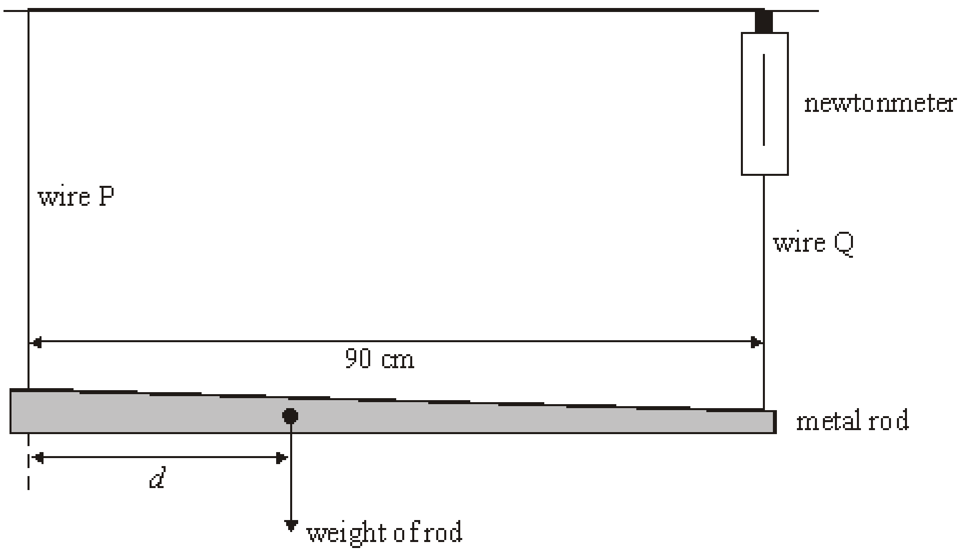
(ii) Calculate the resultant force necessary to produce this acceleration.

answer = ...N

(2)

(Total 10 marks)

Q3. The figure below shows an apparatus used to locate the centre of gravity of a non-uniform metal rod.



The rod is supported horizontally by two wires, P and Q and is in equilibrium.

(a) State **two** conditions that must be satisfied for the rod to be in equilibrium.

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(2)

(b) Wire Q is attached to a newtonmeter so that the force the wire exerts on the rod can be measured. The reading on the newtonmeter is 2.0 N and the weight of the rod is 5.0 N.
Calculate

(i) the force that wire P exerts on the rod,

....

(ii) the distance *d*.

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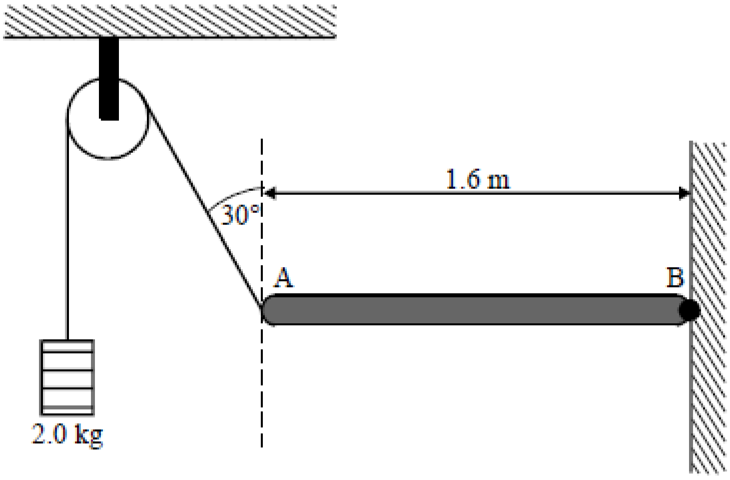
(3)

(Total 5 marks)

Q4. The diagram shows a uniform bar, AB, which is 1.6 m long and freely pivoted to a wall at B. The bar is maintained horizontal and in equilibrium by an angled string which passes over a pulley and which carries a mass of 2.0 kg at its free end.



(a) The pulley is positioned as shown in the diagram, with the string at 30° to the vertical.

(i) Calculate the tension, T, in the string.

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(ii) Show that the mass of the bar is approximately 3.5 kg.

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(4)

(b) A mass, M, is attached to the bar at a point 0.40 m from A. The pulley is moved

horizontally to change the angle made by the string to the vertical, and to maintain the rod horizontal and in equilibrium.
Determine the largest value of the mass, M, for which this equilibrium can be maintained.

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(4)
(Total 8 marks)

Q5.(a) State the principle of moments.

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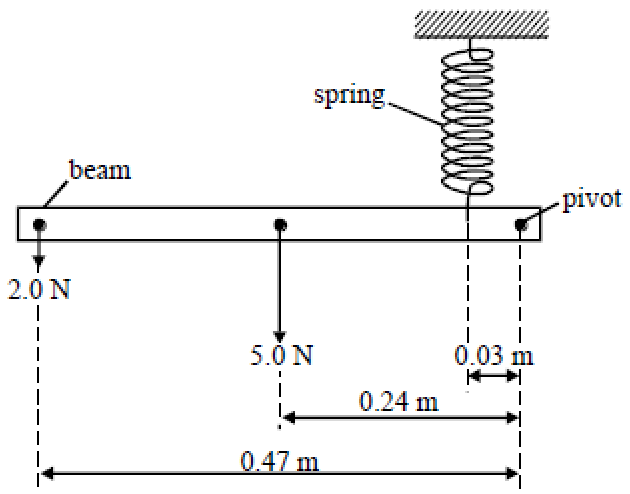
(3)

(b) The diagram below shows a horizontal beam pivoted close to one end. The beam is supported by a spring and is loaded with weights of 2.0 N and 5.0 N as shown. All dimensions are marked on the diagram **and are measured from the pivot**.

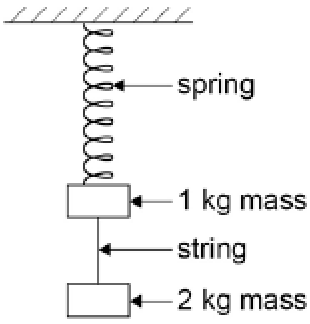


By taking moments about the pivot, calculate the tension in the spring when the beam is horizontal.

Tension = ...

(3)
(Total 6 marks)

Q6. Two masses hang at rest from a spring, as shown in the diagram. The string separating the masses is burned through.

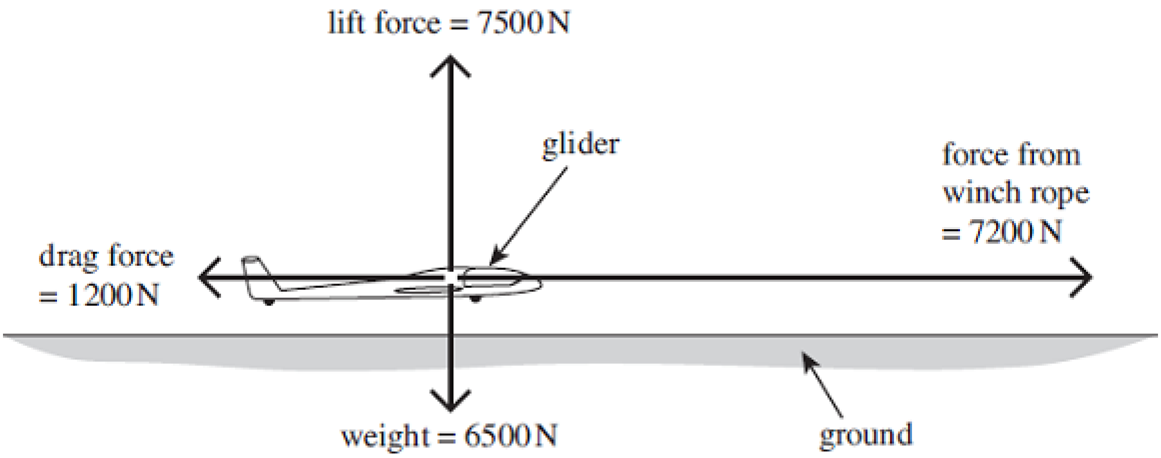


Which of the following gives the accelerations of the two masses as the string breaks?
acceleration of free fall = g

	acceleration of 1 kg mass upwards in m s^{-2}	acceleration of 2 kg mass downwards in m s^{-2}	
A	3 g	1 g	
B	2 g	2 g	
C	2 g	1 g	
D	1 g	1 g	

(Total 1 mark)

Q7. Gliders can be launched with a winch situated on the ground. The winch pulls a rope that is attached to the glider. The diagram below shows the forces acting on the glider at one instant during the launch.



(a) The combined weight of the glider and pilot is 6500 N.

(i) Show that the magnitude of the resultant force acting on the glider is about 6100 N.

(2)

(ii) Calculate the angle between this resultant force and the horizontal.

angle .... degrees

(2)

(iii) Calculate the resultant acceleration of the glider in the diagram above.

resultant acceleration .... m s^{-2}

(2)

(b) The glider climbs a vertical distance of 600 m in 55 s. The average power input to the winch motor during the launch is 320 kW.

(i) Calculate the gain in gravitational potential energy (gpe) of the glider.

gain in gpe .... J

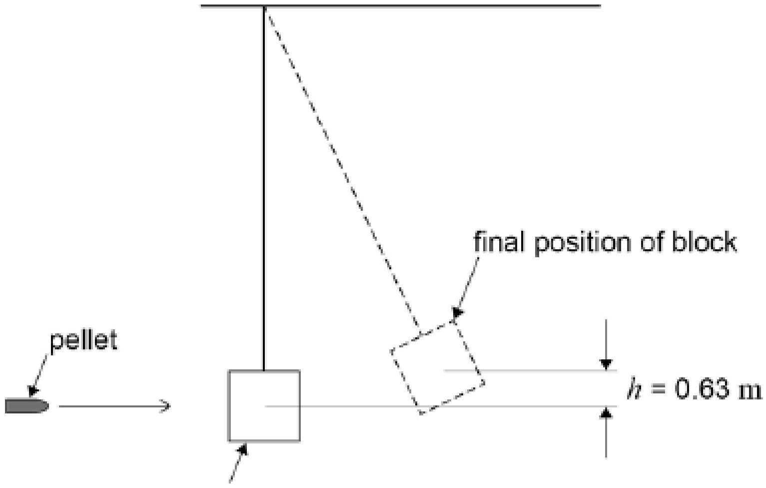
(2)

(ii) Calculate the percentage efficiency of the winch system used to launch the glider. Assume the kinetic energy of the glider after the launch is negligible.

efficiency .... %

(3)
(Total 11 marks)

Q8. The speed of an air rifle pellet is measured by firing it into a wooden block suspended from a rigid support.
The wooden block can swing freely at the end of a light inextensible string as shown in the figure below.



A pellet of mass 8.80 g strikes a stationary wooden block and is completely embedded in it. The centre of mass of the block rises by 0.63 m. The wooden block has a mass of 450 g.

(a) Determine the speed of the pellet when it strikes the wooden block.

speed = ... m s^{-1}

(4)

(b) The wooden block is replaced by a steel block of the same mass.
The experiment is repeated with the steel block and an identical pellet. The pellet rebounds after striking the block.

Discuss how the height the steel block reaches compares with the height of 0.63 m reached by the wooden block. In your answer compare the energy and momentum changes that occur in the two experiments.

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(4)

(c) Discuss which experiment is likely to give the more accurate value for the velocity of the pellet.

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(2)
(Total 10 marks)

Q9. Water of density 1000 kg m^{-3} flows out of a garden hose of cross-sectional area 7.2×10^{-4} m^2 at a rate of 2.0×10^{-4} m^3 per second. How much momentum is carried by the water leaving the hose per second?

A 5.6×10^{-5} N s

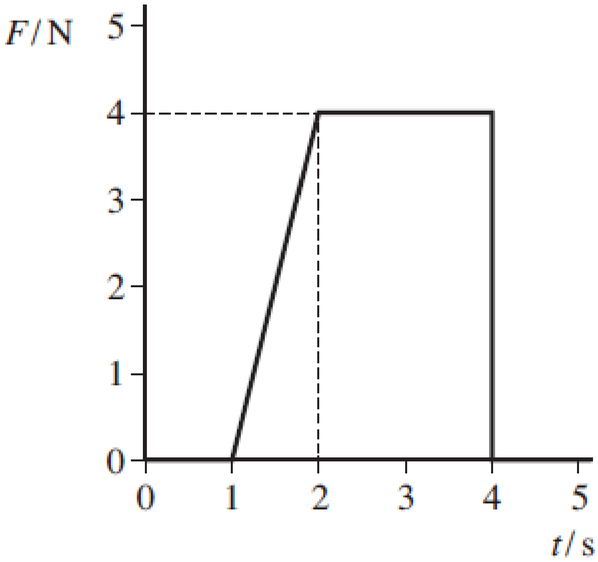
B 5.6×10^{-2} N s

C 0.20 N s

D 0.72 N s

(Total 1 mark)

Q10. The graph shows how the resultant force, *F*, acting on a body varies with time, *t*.



What is the change in momentum of the body over the 5 s period?

A 2N s

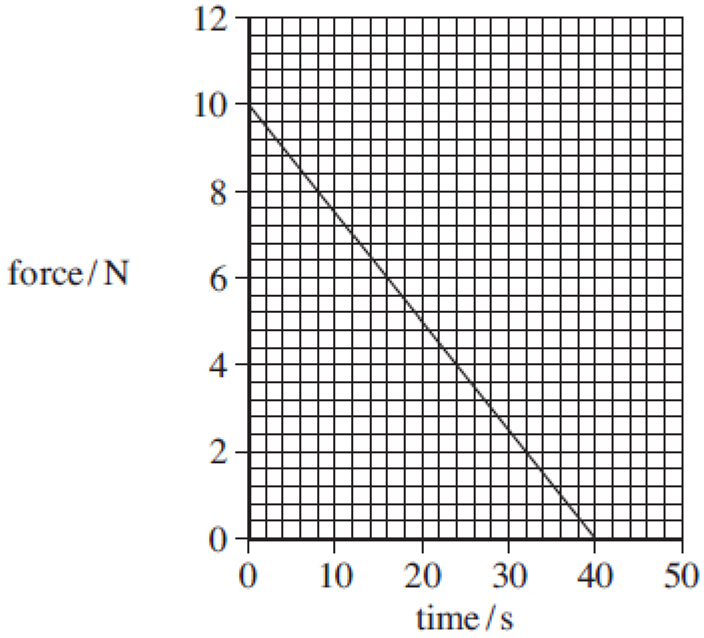
B 8N s

C 10N s

D 12N s

(Total 1 mark)

Q11. The graph shows how the force acting on a body changes with time.



The body has a mass of 0.25 kg and is initially at rest. What is the speed of the body after 40 s assuming no other forces are acting?

A 200 ms^{-1}

B 400 ms^{-1}

C 800 ms^{-1}

D 1600 ms^{-1}

(Total 1 mark)

Q12.(a) Collisions can be described as *elastic* or *inelastic*. State what is meant by an inelastic collision.

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(1)

(b) A ball of mass 0.12 kg strikes a stationary cricket bat with a speed of 18 m s^{-1}. The ball is in contact with the bat for 0.14 s and returns along its original path with a speed of 15 m s^{-1}.

Calculate

(i) the momentum of the ball before the collision,

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(ii) the momentum of the ball after the collision,

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(iii) the total change of momentum of the ball,

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(iv) the average force acting on the ball during contact with the bat,

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(v) the kinetic energy lost by the ball as a result of the collision,

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(6)
(Total 7 marks)

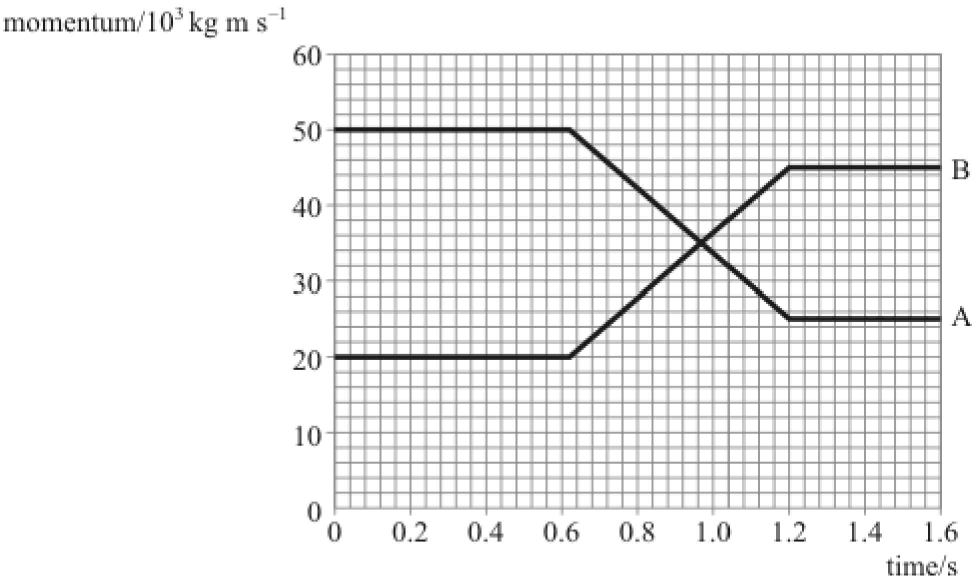
Q13. A body X moving with a velocity *v* makes an elastic collision with a stationary body Y of equal mass on a smooth horizontal surface.

Which line, **A** to **D**, in the table gives the velocities of the two bodies after the collision?

	velocity of X	**velocity of Y**
A	$\frac{v}{2}$	$-\frac{v}{2}$
B	$-\frac{v}{2}$	$\frac{v}{2}$
C	v	0
D	0	v

(Total 1 mark)

Q14. The graph shows how the momentum of two colliding railway trucks varies with time. Truck **A** has a mass of 2.0 × 10^4 kg and truck **B** has a mass of 3.0 × 10^4 kg. The trucks are travelling in the same direction.



(a) Calculate the change in momentum of

(i) truck **A**,

....

(ii) truck **B.**

....

(4)

(b) Complete the following table.

	Initial velocity/m s^{-1}	Final velocity/m s^{-1}	Initial kinetic energy/J	Final kinetic energy/J
truck **A**				
truck **B**				

(4)

(c) State and explain whether the collision of the two trucks is an example of an elastic collision.

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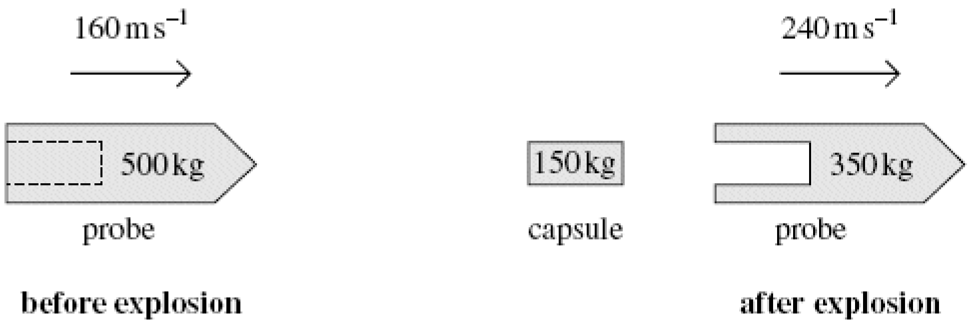
(3)
(Total 11 marks)

Q15. Deep space probes often carry modules which may be ejected from them by an explosion. A space probe of total mass 500 kg is travelling in a straight line through free space at 160 m s^{-1} when it ejects a capsule of mass 150 kg explosively, releasing energy. Immediately after the explosion the probe, now of mass 350 kg, continues to travel in the original straight line but travels at 240 m s^{-1}, as shown in the figure below.



(a) Discuss how the principles of conservation of momentum and conservation of energy apply in this instance.

The quality of your written communication will be assessed in this question.

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(6)

(b) (i) Calculate the magnitude of the velocity of the capsule immediately after the explosion and state its direction of movement.

magnitude of velocity = ... m s^{-1}

direction of movement ....

(3)

(ii) Determine the total amount of energy given to the probe and capsule by the explosion.

answer = ... J

(4)
(Total 13 marks)

Q16.A car exerts a driving force of 500 N when travelling at a constant speed of72 km h^{-1} on a level track. What is the work done in 5 minutes?

A 3.0×10^6 J

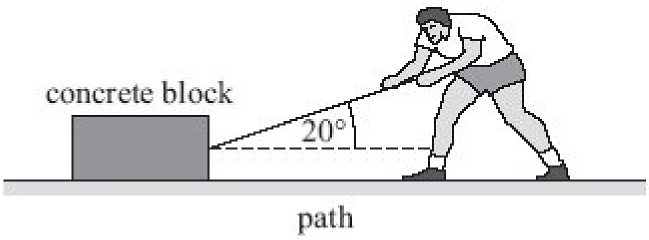
B 2.0×10^6 J

C 2.0×10^5 J

D 1.1×10^5 J

(Total 1 mark)

Q17. The diagram below shows a man participating in a 'strong man' competition. The event requires the man to haul a concrete block along a horizontal path for a distance of 15 m. The frictional force between the block and the path is 2800 N.



(a) The rope is inclined at an angle of 20° to the horizontal.
Calculate the minimum force that the man must exert on the rope to move the block.

force .... N

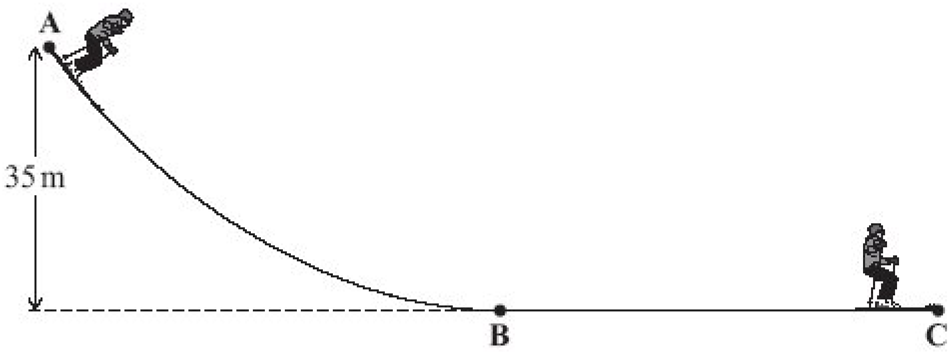
(1)

(b) Calculate the minimum work that the man has to do to complete the event.

work done .... J

(1)
(Total 2 marks)

Q18. The diagram below shows the path of a skier who descends a slope **AB**.



The skier starts from rest at **A** and eventually comes to rest again at **C** on the horizontal surface **BC**.

(a) (i) The slope **AB** has a vertical height of 35 m. The total mass of the skier is 65 kg.

Show that the skier's loss in gravitational potential energy is about 20 kJ.

(1)

(ii) The kinetic energy of the skier at point **B** is 11 000 J.
Show that the skier's speed at point **B** is about 18 m s^{-1}.

(2)

(iii) The average retarding force acting on the skier is 140 N.
Calculate the distance travelled between **A** and **B.**

distance travelled .... m

(2)

(iv) Describe **two** ways in which the retarding force may arise.

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(3)

(b) The skier decelerates uniformly between **B** and **C** at 2.8 m s^{-2}.

(i) Calculate the time taken to travel from **B** to **C**.

time .... s

(2)

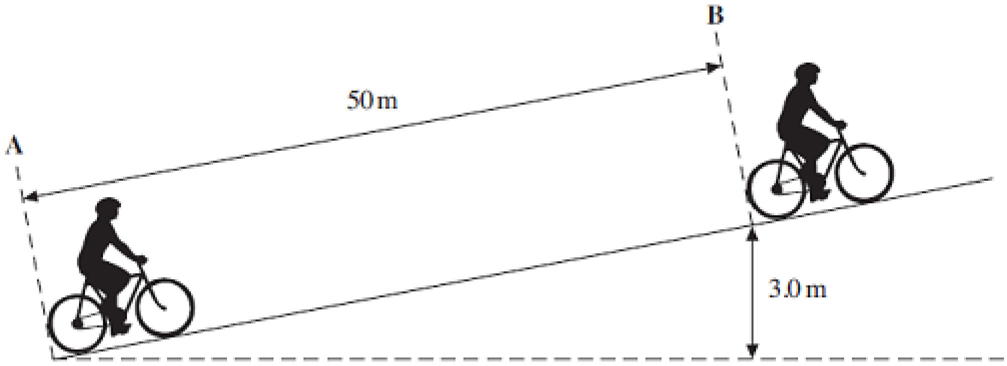
(ii) Calculate the distance **BC**.

distance .... m

(2)

(Total 12 marks)

Q19. An 'E-bike' is a bicycle that is assisted by an electric motor. The figure below shows an E-bike and rider with a total mass of 83 kg moving up an incline.



(a) (i) The cyclist begins at rest at **A** and accelerates uniformly to a speed of 6.7 m s^{-1} at **B**.
The distance between **A** and **B** is 50 m.
Calculate the time taken for the cyclist to travel this distance.

answer = ... s

(2)

(ii) Calculate the kinetic energy of the E-bike and rider when at **B**. Give your answer to an appropriate number of significant figures.

answer = ... J

(2)

(iii) Calculate the gravitational potential energy gained by the E-bike and rider between **A** and **B**.

answer = ... J

(2)

(b) Between **A** and **B**, the work done by the electric motor is 3700 J, and the work done by the cyclist pedalling is 5300 J.

(i) Calculate the wasted energy as the cyclist travels from **A** to **B**.

answer = ... J

(2)

(ii) State **two** causes of this wasted energy.

Cause 1 ....

....

Cause 2 ....

....

(2)
(Total 10 marks)

Q20. The world record for a high dive into deep water is 54 m.

(a) Calculate the loss in gravitational potential energy (gpe) of a diver of mass 65 kg falling through 54 m.

loss in gpe = ... J

(2)

(b) Calculate the vertical velocity of the diver the instant before he enters the water.

Ignore the effects of air resistance.

velocity = ... ms^{-1}

(2)

(c) Calculate the time taken for the diver to fall 54 m. Ignore the effects of air resistance.

time = ... s

(2)

(d) Explain, with reference to energy, why the velocity of the diver is independent of his mass if air resistance is insignificant.

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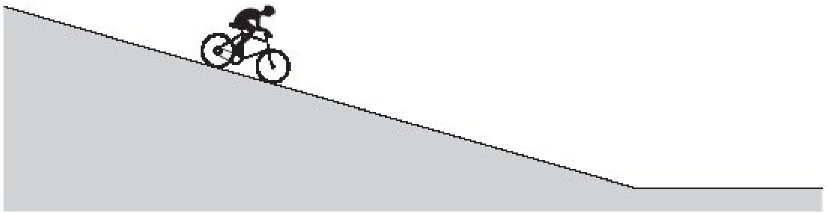
(3)
(Total 9 marks)

Q21. A cyclist **pedals** downhill on a road, as shown in the diagram below, from rest at the top of the hill and reaches a horizontal section of the road at a speed of 16 m s^{-1}. The total mass of the cyclist and the cycle is 68 kg.



(a) (i) Calculate the total kinetic energy of the cyclist and the cycle on reaching the horizontal section of the road.

answer .... J

(2)

(ii) The height difference between the top of the hill and the horizontal section of road is 12 m.
Calculate the loss of gravitational potential energy of the cyclist and the cycle.

answer .... J

(2)

(iii) The work done by the cyclist when pedalling downhill is 2400 J. Account for the difference between the loss of gravitational potential energy and the gain of kinetic energy of the cyclist and the cycle.

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(3)

(b) The cyclist stops pedalling on reaching the horizontal section of the road and slows to a standstill 160 m further along this section of the road. Assume the deceleration is uniform.

(i) Calculate the time taken by the cyclist to travel this distance.

answer................................ s

(3)

(ii) Calculate the average horizontal force on the cyclist and the cycle during this time.

answer .... N

(3)
(Total 13 marks)

M1.B

[1]

M2. (a) (i) (moment = 520 x 0.26) = 140 (135.2) ✓

Nm ✓

2

(ii) **180 x 0.41** and **0.63 X** seen ✓

135.2 = 180 x 0.41 + 0.63 X ✓ ecf from (a)(i)

(X = (135.2 – 73.8) / 0.63)

= 97 ✓ (N) (97.46) allow 105 from use of 140Nm ecf from (a)(i)

3

(iii) (520 – (180 + 97.46))

= 240 ✓ (242.5 N) ecf (or from correct moments calculation)

1

(b) (i) ($v^2 = u^2 + 2as$)

$9.3^2 = 2 \times a \times 35$ OR $9.3^2 = 70a$ OR $a = v^2/2s$
OR $9.3^2/70$ ✓

OR correct alternative approach

1.2 (1.2356) ✓ (m s^{-2})

2

(ii) *(m = W/g)* = 520/9.81 (= 53.0) ✓ (kg)

F = ma = 53 × 3bi (1.2356) = 65 (N) (65.49) ✓

accept use of 1.2 giving 64(63.6) , allow 53 x 124 = 65.7

2

[10]

M3. (a) resultant force zero **(1)**
resultant torque about any point zero **(1)**

2

(b) (i) force due to wire P = 5.0 - 2.0 = 3.0 N **(1)**

(ii) (moments give) 5.0 × *d* = 2.0 × 0.90 **(1)**
d= 0.36 m **(1)**

3

[5]

M4.(a) (i) T = 2.0 × 9.8 = 19.6 N **(1)**

(ii) moments about B

19.6cos30° × 1.6 **(1)** = mg × 0.8 **(1)**

mass = $\frac{33.9}{9.8}$ **(1)** (= 3.46 kg)

(4)

(b) maximum support when wire vertical **(1)**

moments about B

2.0 × 9.8 × 1.6 = (M × 9.8 × 1 .2) **(1)** + 33.9 × 0.8 **(1)**

∴ M = 0.36 kg **(1)**

[n.b. 0.33 kg if 3.5 used]

(4)

[8]

M5.(a) equilibrium statement **B1**

clockwise moment = anticlockwise moment **B1**

sum of anticlockwise moments = sum of clockwise **B1**

(3)

(b) attempt to use moment formula

[force x distance is needed as minimum] **B1**

T × 0.03 = 5.0 × 0.24 + 2.0 × 0.47 **B1**

= 1.20 + 0.94 = 2.14 N m; T = 71 N (71.3) **B1**

(3)

[6]

M6.C

[1]

M7.(a) (i) 1000(N) AND 6000(N) seen

Independent marks

OR

$F = \sqrt{(1000)^2 + (6000)^2}$ ✓ allow incorrect values seen

= **6083** (N) (= 6100) ✓ More than 2 sf seen

Allow full credit for appropriate scale drawing

Ignore rounding errors in 3rd sig fig.

2

(ii) tanϴ = 1000 / 6000 or correct use of sin or cos ✓

ϴ = 9.5 (9.46°) ✓
Allow range 9.4 − 10.4

Use of cos yields 10.4
Allow use of 6100
Some working required for 2 marks.
Max 1 mark for correct calculation of vertical angle (range 79.6 − 80.6) some working must be seen

2

(iii) (*m* = *W/g* =) 6500 / 9.81 (= 662.6 kg) ✓
(*a* = *F* / *m* = 6083 / 662.6)
= 9.2 (ms^{-2}) ✓ (9.180)

Use of weight rather than mass gets zero
Correct answer on its own gets 2 marks
Penalise use of g=10 in this question part only (max 1)

2

(b) (i) = 6500 × 600 ✓ (662.6 × 9.81 × 600)
= 3 900 000 ✓ (J)

Look out for W x g x h which gives 39000000 (gets zero)
Correct answer on its own gets 2 marks
Do not allow use of 1/2 mv^2 (= 39 000)

2

(ii) (E= Pt =) 320 000 ×; 55 (= 17 600 k J)
OR P= 1(b)(i) / 55 (7.09 × 10^4) ✓
3.9 / 17.6 OR 70.9 / 320 OR = 0.22(16) ✓ ecf from first line

Some valid working required for 3 marks

conversion to a percentage (= 22 %) ✓

Look out for physics error: Power / time (320/55) then use of inverted efficiency equation yielding correct answer
Do not allow percentages >= 100% for third mark

3

[11]

M8.(a) Max GPE of block = Mgh = 0.46 × 9.81 × 0.63 = 2.84 J ✓

The first mark is for working out the GPE of the block

1

Initial KE of block = ½ Mv^2 = 2.84 J

Initial speed of block v^2 = (2 × 2.84) / 0.46

v = 3.51 ms^{-1} ✓

The second mark is for working out the speed of the block initially

1

momentum lost by pellet = momentum gained by block

= Mv = 0.46 × 3.51 = 1.61 kg m s^{-1} ✓

The third mark is for working out the momentum of the block (and therefore pellet)

1

Speed of pellet = 1.58 / m = 1.58 / 8.8 × 10^{-3} = 180 ms^{-1} (183) ✓

The final mark is for the speed of the pellet

1

At each step the mark is for the method rather than the calculated answer

Allow one consequential error in the final answer

(b) As pellet rebounds, change in momentum of pellet greater and therefore the change in momentum of the block is greater ✓

Ignore any discussion of air resistance

1

Initial speed of block is greater ✓

1

(Mass stays the same)

Initial KE of block greater ✓

1

Therefore height reached by steel block is greater than with wooden block ✓

1

(c) Calculation of steel method will need to assume that collision is elastic so that change of momentum can be calculated ✓

1

This is unlikely due to deformation of bullet, production of sound etc. ✓

1

And therefore steel method unlikely to produce accurate results.

[10]

M9.B

[1]

M10.C

[1]

M11. C

[1]

M12.(a) kinetic energy is not conserved **(1)**

(1)

(b) (i) ($p = mv$ gives) p = 0.12 × 18 = 2.2 N s **(1)** (2.16 N s)

(ii) p = 0.12 × (–15) = –1.8 N s **(1)**

(iii) Δp = 2.2 – (–1.8) = 4.0 N s (3.96 N s) **(1)**
(allow e.c.f. from(i) and(ii))

(iv) $\left(F = \frac{\Delta(mv)}{\Delta t} \text{ gives}\right) F = \frac{3.96}{0.14}$ **(1)**

= 28 N **(1)** (28.3 N)
(allow e.c.f. from (iii))

(v) (E_k = ½mv^2 gives) E_k = 0.5 × 0.12 × (18^2 – 15^2) = 5.9 J **(1)**

(6)

[7]

M13. D

[1]

M14. (a) (i) (change in momentum of A) = – **(1)** 25 × 10^3 **(1)**
kg m s^{-1} (or N s) **(1)**

(ii) (change in momentum of B) = 25 × 10^3 kg m s^{-1} **(1)**

4

(b)

	initial vel/m s^{-1}	final vel/m s^{-1}	initial k.e./J	final k.e./J
truck A	2.5	1.25	62500	15600
truck B	0.67	1.5	6730	33750
	(1)	**(1)**	**(1)**	**(1)**

4

(c) not elastic **(1)**
because kinetic energy not conserved **(1)**
kinetic energy is greater before the collision (or less after) **(1)**
[or justified by correct calculation]

3

[11]

M15. (a) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate states that momentum is conserved, supported by reasoning to explain why the conditions required for momentum conservation are satisfied in this case.

The candidate also gives a statement that total energy is conserved, giving detailed consideration of the energy conversions which take place, described in the correct sequence, when there is an explosion on a body that is already moving.

The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.

Momentum

- momentum is conserved because there are no external forces acting on the overall system (probe plus capsule) – or because it's free space
- they are moving in free space and are therefore so far from large masses that gravitational forces are negligible
- during the explosion, there are equal and opposite forces acting between the probe and the capsule
- these are internal forces that act within the overall system
- because momentum has to be conserved, and it is a vector, the capsule must move along the original line of movement after the explosion

Energy

- total energy is always conserved in any physical process because energy can be neither created nor destroyed
- however, energy may be converted from one form to another
- the probe is already moving and has kinetic energy
- in the explosion, some chemical energy is converted into kinetic energy (and some energy is lost in heating the surroundings)
- the system of probe and capsule has more kinetic energy than the probe had originally, because some kinetic energy is released by the explosion

max 6

(b) (i) conservation of momentum gives (500 × 160) = 150 v + (350 × 240) **(1)**
from which v = (−)26(.7) (m s^{-1}) **(1)**

direction: opposite horizontal direction to larger fragment [**or** to the left, **or** backwards] **(1)**

3

(ii) initial E_k = ½ × 500 × 160^2 **(1)** (= 6.40 × 10^6 J)

final E_k = (½ × 350 × 240^2) + (½ × 150 × 26.7^2) **(1)** (= 1.01 × 10^7 J)

energy released by explosion = final E_k − initial E_k **(1)**

= 3.7 × 10^6 (J) **(1)**

4

[13]

M16.C

[1]

M17. (a) 2800/cos 20 = 3000 (2980)N **(1)**

B1

1

(b) 42000J **(1)**

B1

1

[2]

M18. (a) (i) 65 × 9.8 × 35 seen and evaluated to 22295 or 2231 or 22300J

B1

(ii) correct substitution of 65 kg and either 11000J or 18 m s^{-1} in ke formula seen

B1

18.4 (18.397) (m s^{-1}) to at least 3 sf

B1

(iii) distance = energy loss/force or work done/force or numerical equivalent

C1

64-64.3 using E_p = 20kJ or 79 – 81(m) using 22.3 kJ

A1

(iv) friction

B1

air resistance

B1

further detail eg friction at ski-ice surface

or caused by need to move air when passing through it

B1

8

(b) (i) time = Δ*v*/*a* or numerical equivalent

C1

6.4(3) – 6.6(6.57) (s)

A1

(ii) use of appropriate kinematic equation

C1

(57.8 – 60.4) 58 m or 60 (m) to 2 sf

A1

4

[12]

M19.(a) (i) *(s = ½(u + v) t) t = 2s/v* ✓ (correct rearrangement, either symbols or values)

(= 100/6.7) = 15 ✓ (s) (14.925)

or alternative correct approach

2

(ii) ($KE = 1/2mv^2$ = ½ × 83 × 6.7^2) = 1900 ✓ (1862.9 J)

2 sf ✓

2

(iii) GPE = 83 × 9.81 × 3.0 ✓ penalise use of 10, allow 9.8

= 2400 (2443 J) ✓ do not allow 2500 (2490) for use of g = 10

2

(b) (i) 5300 + 3700 (or 9000 seen)

or – 2443 – 1863 (or (–) 4306 seen) ✓

= 4700 (J) ✓ (4694) ecf from parts aii & aiii

2

(ii) mention of friction and appropriate location given ✓

mention of **air** resistance (or drag) ✓

do not allow energy losses or friction within the motor

do not allow energy losses from the cyclist

must give a **cause** not just eg 'heat loss in tyres'

2

[10]

M20.(a) *($Ep = mg\Delta h$)*

= 65 × 9.81 × 54 ✓

= $3.44 \times 10^4 = 3.4 \times 10^4$ (J) ✓ (34433)

max 1 if g =10 used (35100 J)

Correct answer gains both marks

2

(b) $v = \sqrt{\frac{2\,Ep}{m}}$ OR $v = \sqrt{\frac{2 \times 34433}{65}}$ ✓ $= 33\ (32.55\ \text{ms}^{-1})$ ✓ ecf 1(a)

allow 32 (32.3) for the use of 34000

allow 32.6

OR correct use of $v^2 = 2\,g\,s$

don't penalise g = 10 (32.863)

2

(c) ($s = 1/2\ gt^2$ or other kinematics equation)

$t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2 \times 54}{9.81}}$ ✓ $= 3.318 = 3.3\,(\text{s})$ ✓

With use of g= 9.8 or 9.81 or 10 and / or various suvat equations, expect range 3.2 to 3.4 s.

No penalty for using g= 10 here.

ecf from 1(b) if speed used

2

(d) (all G)PE (lost) is transferred to KE

no (GP)E transferred to 'heat' / 'thermal' / internal energy

OR ✓

Must imply that all GPE is transferred to KE. E.g. accept 'loss of GPE is gain in KE' but not: 'loses GPE and gains KE'.

(therefore) $mg\Delta h \; \frac{1}{2}mv^2$ ✓
mass cancels. ✓

Accept 'm's crossed out

3

[9]

M21. (a) (i) ($E_K = \frac{1}{2}mv^2$ =) 0.5 × 68 × 16^2 **(1)** = **8700** or 8704(J) **(1)**

(ii) ($\Delta E_P = mg\Delta h$ =) 68 × 9.8(1) × 12 **(1)** = **8000** or 8005 (J) **(1)**

(iii) any **three** from

gain of kinetic energy **>** loss of potential energy **(1)**

(because) cyclist does work **(1)**

energy is wasted (on the cyclist and cycle) due to air resistance or friction or transferred to thermal/heat **(1)**

KE = GPE + W – energy 'loss' **(1)** (owtte)

energy wasted (= 8000 + 2400 - 8700) = 1700(J) **(1)**

7

(b) (i) (u = 16 m s^{-1}, s = 160 m, v = 0, rearranging $s = \frac{1}{2}(u + v)t$ gives)

160 = ½ × 16 × t or $t = \frac{2s}{(u+v)}$ or correct alternative

$\frac{2 \times 160}{16}$ (gets 2 marks) **(1)** = 20s **(1)**

(ii) acceleration $a = (\frac{v-u}{t} =) \frac{0-16}{20}$ ecf (b) (i) **(1)** = (–) **0.80** (m s^{-2})

resultant force $F = ma$ = 68 × (–) 0.80 **(1)** = (–) 54 (N) **(1)** or 54.4
or (work done by horizontal force = loss of kinetic energy
work done = force × distance gives)

$$\text{force} = \frac{\text{(loss of kinetic) energy}}{\text{distance}}\ \textbf{(1)} = \frac{8700\ \text{J}}{160\ \text{m}}$$

ecf (a) (i) **(1)** = 54 (N) **(1)**

6

[13]