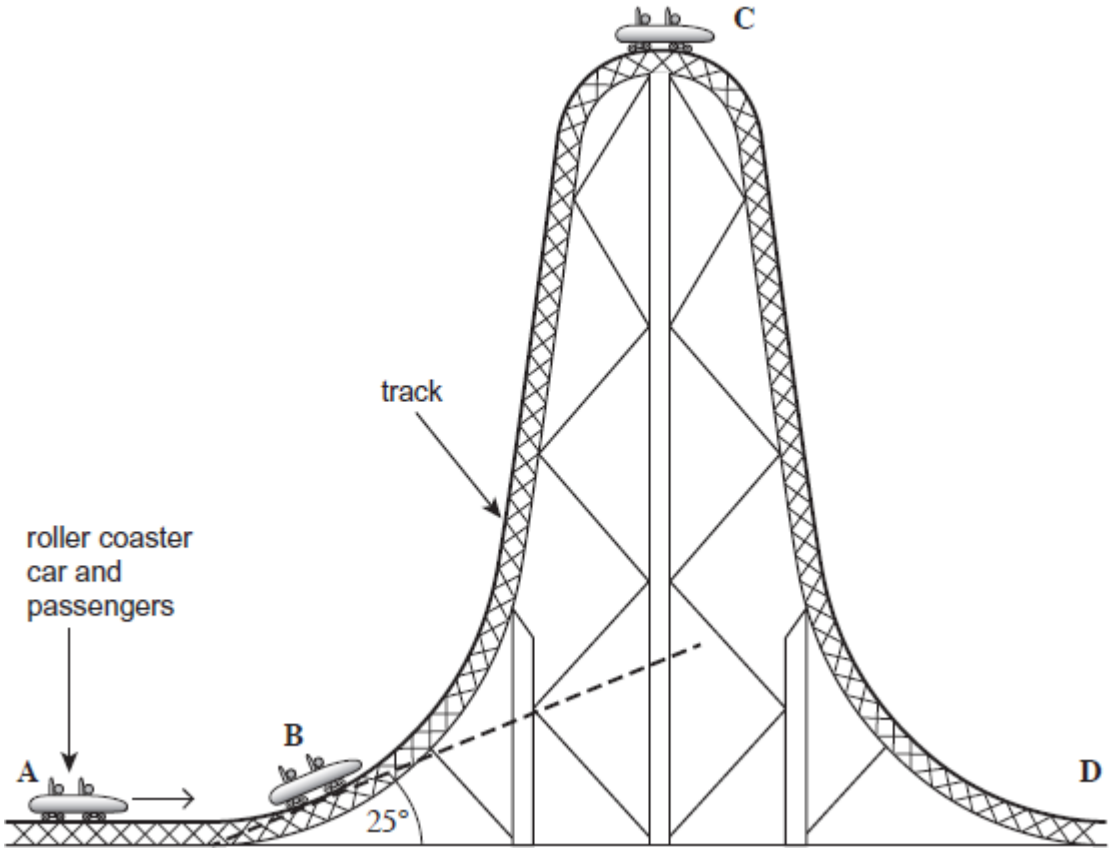
Mechanics Past Paper Questions Name .....

Q1. The following figure shows a roller coaster car which is accelerated from rest to a speed of 56 m s^{-1} on a horizontal track, **A**, before ascending the steep part of the track. The roller coaster car then becomes stationary at **C**, the highest point of the track. The total mass of the car and passengers is 8300 kg.



(a) The angle of the track at **B** is 25° to the horizontal. Calculate the component of the weight of the car and passengers acting along the slope when the car and passengers are in position **B** as shown in the image above.

component of weight ..... N

(2)

(b) (i) Calculate the kinetic energy of the car including the passengers when travelling at 56 m s^{-1}.

kinetic energy ..... J

(2)

(ii) Calculate the maximum height above **A** that would be reached by the car and passengers if all the kinetic energy could be transferred to gravitational potential energy.

maximum height ..... m

(2)

(c) The car does not reach the height calculated in part (b).

(i) Explain the main reason why the car does not reach this height.

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(2)

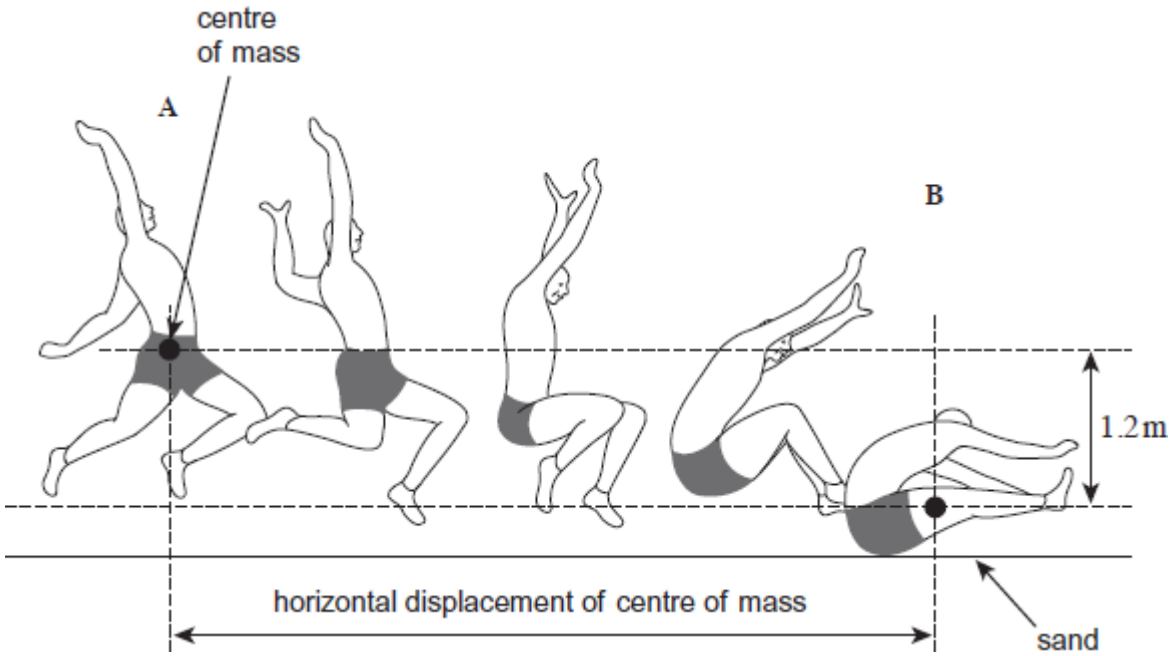
(ii) The car reaches point **C** which is at a height of 140 m above **A**. Calculate the speed that the car would reach when it descends from rest at **C** to its original height from the ground at **D** if 87% of its energy at **C** is converted to kinetic energy.

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

(2)

(Total 10 marks)

Q2. The motion of a long jumper during a jump is similar to that of a projectile moving under gravity. The figure below shows the path of an athlete above the ground during a long jump from half-way through the jump at position **A**, to position **B** at which contact is made with sand on the ground. The athlete is travelling horizontally at **A**.



(a) During this part of the jump, the centre of mass of the athlete falls 1.2 m.

(i) Calculate the time between positions **A** and **B**.

time ..... s

(3)

(ii) The athlete is moving horizontally at **A** with a velocity of 8.5 m s^{-1}. Assume there is no air resistance. Calculate the horizontal displacement of the centre of mass from **A** to **B**.

horizontal displacement ..... m

(2)

(b) (i) The athlete in the image above slides horizontally through the sand a distance of 0.35 m before stopping.

Calculate the time taken for the athlete to stop. Assume the horizontal component of the resistive force from the sand is constant.

time ..... s

(2)

(ii) The athlete has a mass of 75 kg. Calculate the horizontal component of the resistive force from the sand.

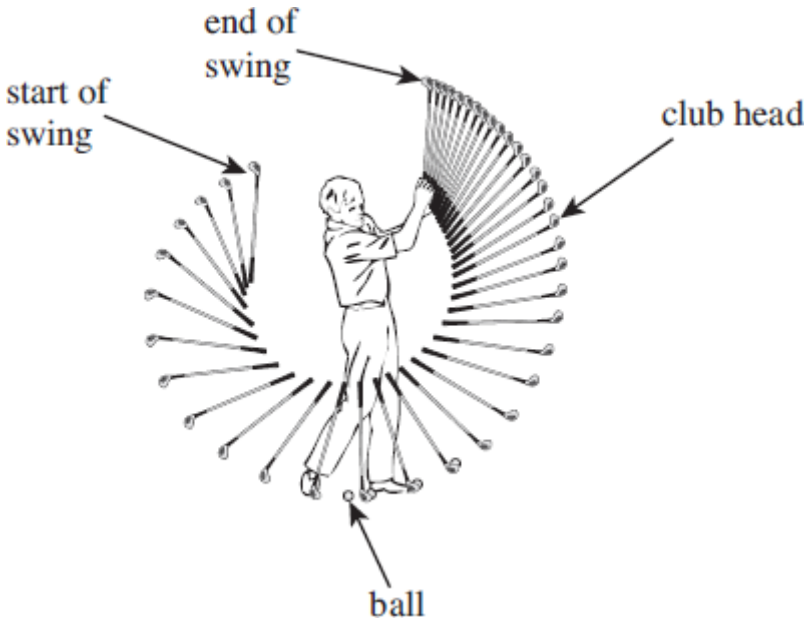
horizontal component of resistive force ..... N

(3)

(Total 10 marks)

Q3. When hitting golf balls long distances, golfers *follow through* with the swing. Doing this increases the time for which the club head is in contact with the ball.

The figure below is a stroboscopic photograph of a golf swing. The images were taken at equal time intervals.



(a) Sketch, on the axes below, how the speed of the club head varies with time over the whole swing.

(2)

(b) Explain in terms of the impulse acting on the ball the advantage to the golfer of following through with the swing.

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(2)

(c) The club head is in contact with the ball for a time of 180 μs. The mass of the club head is 0.17 kg and that of the ball is 0.045 kg. At the moment of contact the ball is at rest and the club head is moving with a speed of 35 ms^{-1}. The ball moves off with an initial speed of 58 ms^{-1}.

(i) Calculate the average force acting on the ball while the club head is in contact with it.

average force on ball ..... N

(2)

(ii) Deduce the average force acting on the club head due to its collision with the ball.

average force on club head ..... N

(1)

(iii) Explain why it is not possible to transfer all the kinetic energy of the club head to the ball.

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(2)

(Total 9 marks)

Mechanics Past Paper Questions - Answers

M1.(a) 8300 × 9.81 OR = 81423 ✓
(8300 × 9.81 sin 25)
= 3.4 × 10^4 (N) ✓ (34 411 N) ecf from first line unless g not used
msin25 gets zero
Penalize use of g = 10 here only
(35 077 N)
Allow 9.8 in any question
Correct answer only, gets both marks for all two mark questions

2

(b) (i) ($E_k = ½mv^2$)
= ½ × 8300 × 56^2 ✓
= 1.3 × 10^7 (J) ✓ (13 014 400) allow use of 8300 only
In general: Penalise transcription errors and rounding errors in answers

2

(ii) *mgh* = KE (13 014 400) for *mgh* allow GPE or E_p
OR 13 014 400 / 81 423 ✓
h = 160 (m) ✓ (159.8) ecf 1bi
Allow use of suvat approach

2

(c) (i) (work done) by friction \ drag \ air resistance \ resistive forces ✓
(energy converted) to internal \ thermal energy ✓
Allow 'heat'

2

(ii) 0.87 x (8300 x 9.81 x 140 = 9 917 000) OR $v = \sqrt{\left[\frac{2 \times (9\,917\,000)}{8300}\right]}$ ✓
= 49 (= 48.88 ms^{-1}) ✓
87% of energy for 140m or 160m only for first mark.
Use of 160 (52.26) and / or incorrect or no % (52.4) gets max 1 provided working is shown
Do not credit suvat approaches here

2

[10]

(a) (i) use of $\left(s = \frac{1}{2}gt^2\right)$ OR $t^2 = 2s / g$ ✓

t = $\sqrt{\frac{2 \times 1.2}{9.81}}$ ✓

= 0.49 (0.4946 s) ✓ allow 0.5 do not allow 0.50
Some working required for full marks. Correct answer only gets 2

3

(ii) ($s = vt$)
= 8.5 × 0.4946 ✓ ecf ai
= 4.2 m ✓ (4.20) ecf from ai

2

(b) (i) $\left(s = \frac{1}{2}(u + v)\,t\right)$

$t = \frac{2s}{u(+v)}$ or correct sub into equation above ✓

$= \frac{2 \times 0.35}{8.5}$ $= 8.2 \times 10^{-2}$ (s) ✓ (0.0824) allow 0.08 but not 0.080 or 0.1

Allow alternative correct approaches

2

(ii) $a = (v - u) / t$ OR correct substitution OR a = 103 ✓

(= −8.5) / 8.24×10^{-2} = 103.2)

($F = ma$ =) 75 × (103.2) ✓ ecf from bi for incorrect acceleration due to arithmetic error only, not a physics error (e.g. do not allow a = 8.5. Use of g gets zero for the question.

= 7700 N ✓ (7741) ecf (see above)

Or from loss of KE

Some working required for full marks. Correct answer only gets 2

3

[10]

M3.(a) smooth curve with a maximum value shown

B1

condone non-zero at start and finish

gradient fairly constant or slight increase for half time

B1

falls gradually on second half of swing

B1

oscillations score zero

2 max

(b) impulse is product of force and time

B1

clear reference to impulse

prolonging the time (of contact) increases momentum / velocity

B1

being force time product needed for first mark

2

(c) (i) use of $F=mv/t$ = $0.045 \times 58 / 180 \times 10^{-6}$

C1

use of 35 can gain first mark

or a = 58 / 180 = 3.2×10^{5} (ignore power for first mark) 1.45×10^{4} (N)

A1

2

(ii) $(-)1.45 \times 10^{4}$ (N)

B1

numerically equal to c(i)

1

(iii) club head has inertia

C1

do not credit reference to friction

club head only slows slightly on impact

A1

club head still has kinetic energy / collision not elastic increase in internal energy / □heat' / temperature of ball / club head

treat references to sound neutrally

2 max

[9]