Worked Solutions for ENGAA Papers by Topic

Section 1

Topic: Mechanics

Section 1 Topic	Number of Questions 2016 - 2020
Algebra	34
Calculus	16
Coordinate geometry	11
Electricity	18
Energy	8
Exponentials and logarithms	9
Forces and equilibrium	7
Geometry	40
Kinematics	15
Materials	2
Matter & thermal physics	5
Mechanics	55
Number	11
Probability	3
Radioactivity	14
Ratio and proportion	7
Sequences and series	8
Trigonometry	6
Waves	13

ENGAA S1 2020 - Question 9

9 Two trolleys are moving towards each other along a straight horizontal track.

One trolley has mass 8.0 kg and is travelling to the right at 4.0 m s^{-1}.

The other trolley has mass 2.0 kg and is travelling to the left at 1.0 m s^{-1}.

When the trolleys collide they stick together.

How much kinetic energy is transferred to other forms of energy in the collision?

A 2.0 J

B 18 J

C 20 J

D 28 J

E 35 J

F 40 J

G 45 J

H 65 J

ENGAA S1 2020 - Question 9 - Worked Solution

Conservation of momentum

$$8 \times 4 + 2 \times (-1) = (8 + 2)v$$

$$\therefore v = 3\,\text{ms}^{-1}$$

Energies before & after

$$T = \frac{1}{2}(8)(4)^2 + \frac{1}{2}(2)(1)^2 = 65\text{J}$$

$$T' = \frac{1}{2}(10)(3)^2 = 45J$$

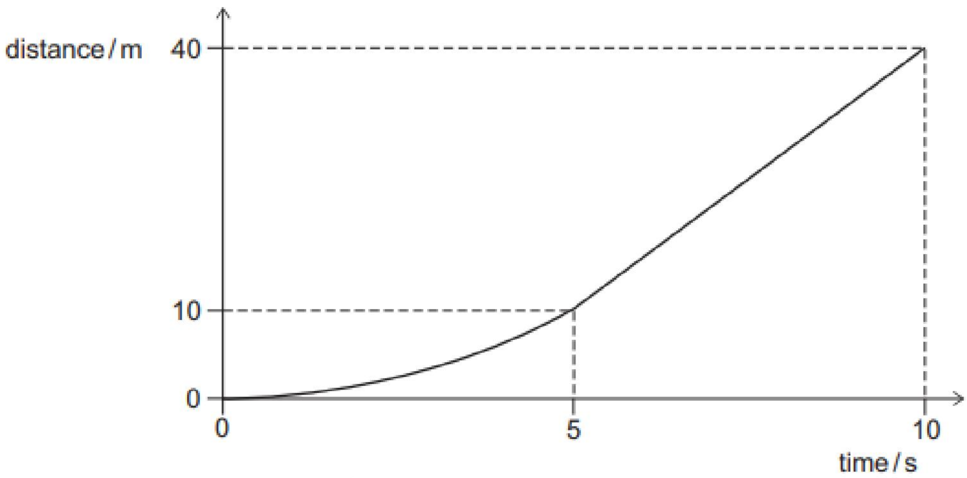
$$T - T' = 20\text{J}$$

Answer is C

ENGAA S1 2020 - Question 11

11 A car of mass 800 kg travels in a straight line along a horizontal road.

The car accelerates **non-uniformly** from rest for 5.0 seconds and then moves at constant speed, as shown in the distance–time graph:



What is the average resultant force acting on the car over the time for which it is accelerating?

A 320 N

B 480 N

C 640 N

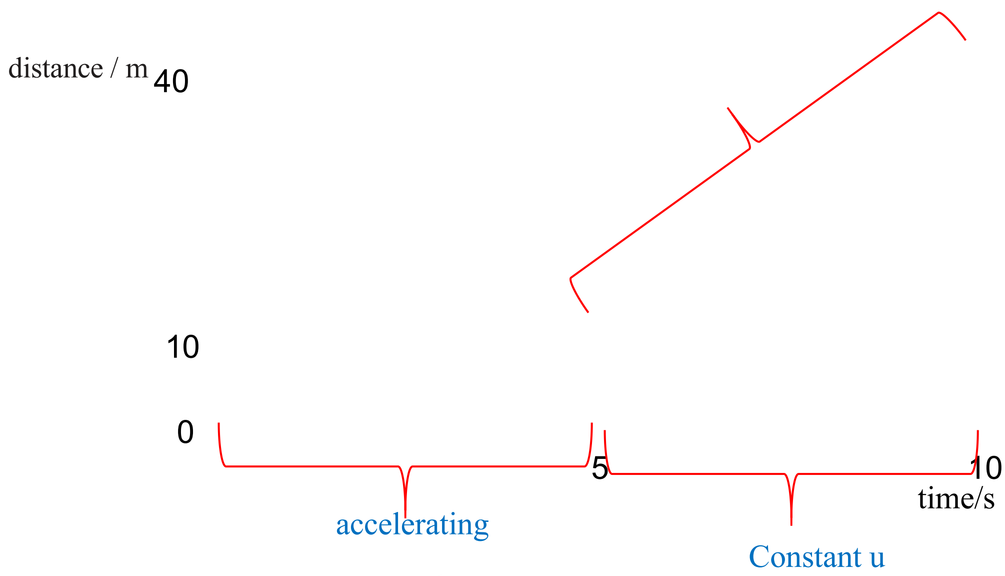
D 960 N

E 1600 N

F 3200 N

G 4800 N

ENGAA S1 2020 - Question 11 - Worked Solution



$$a = \frac{v-u}{t} = \frac{6-0}{5}$$

$a = 1.2ms^{-2}$

$F = ma = 960N$

Answer is D

ENGAA S1 2020 - Question 15

15 A parachutist of mass 80.0 kg drops from a plane travelling at 40.0 m s^{-1}, 2000 m above the Earth's surface.

The parachutist hits the ground at a speed of 5.00 m s^{-1}.

How much work is done by the parachutist against drag forces during the fall?

(Take the Earth's gravitational field strength to be 10.0 N kg^{-1}.)

A 1 535 000 J

B 1 624 000 J

C 1 649 000 J

D 1 663 000 J

E 1 726 000 J

ENGAA S1 2020 - Question 15 - Worked Solution

$$E_{before} = mgh + \frac{1}{2}mv^2$$

$$= 80 \times 10 \times 2000 + \frac{80}{2}.5^2$$

$$= 1664000J$$

$$E_{after} = \frac{1}{2}mv^2 = \frac{80}{2}.5^2$$

$$= 1000J$$

$$E_b - E_a = 1663000J$$

Answer is D

ENGAA S1 2020 - Question 17

17 A light spring of unstretched length 0.10 m has a spring constant of $20\,N\,m^{-1}$. The spring is suspended so that it is vertical and a load of mass 0.050 kg is attached to the end of the spring.

The load is pulled vertically downwards until the length of the spring is 0.30 m. The load is then released.

What is the speed of the load at the instant that the spring returns to its unstretched length?

(gravitational field strength = $10\,N\,kg^{-1}$; assume that resistive forces are negligible)

A $0\,m\,s^{-1}$

B $4.0\,m\,s^{-1}$

C $6.0\,m\,s^{-1}$

D $12\,m\,s^{-1}$

E $16\,m\,s^{-1}$

F $\sqrt{6}\,m\,s^{-1}$

G $\sqrt{12}\,m\,s^{-1}$

H $\sqrt{30}\,m\,s^{-1}$

ENGAA S1 2020 - Question 17 - Worked Solution

$$E_{before} = \frac{1}{2}kx^2 = \frac{1}{2} \times 20 \times (0.3 - 0.1)^2 = \frac{4}{10}J$$

$$E_{after} = mgh + \frac{1}{2}mv^2 = 0.05 \times 10 \times (0.3 - 0.1) + \frac{1}{2} \times 0.05 \times v^2$$

Equating $E_b = E_a$

$$\frac{4}{10} = \frac{1}{10} + \frac{0.05}{2}.v^2$$

$$: \frac{0.05}{2} = \frac{5}{200} = \frac{1}{40}$$

$$v^2 = \frac{3}{10}.\frac{40}{1} \to v = \sqrt{12}$$

Answer is G

ENGAA S1 2020 - Question 19

19 A rocket travelling in space is burning its fuel at a constant rate. By expelling the burnt fuel through a nozzle, the engine is applying a constant force to the rocket.

What is happening to the magnitude of the acceleration of the rocket?

A It is increasing at an increasing rate.

B It is increasing at a constant rate.

C It is increasing at a decreasing rate.

D It is not changing.

E It is decreasing at an increasing rate.

F It is decreasing at a constant rate.

G It is decreasing at a decreasing rate.

ENGAA S1 2020 - Question 19 - Worked Solution

using the product rule, F = $\frac{dP}{dt} = \frac{dm}{dt} . v + \frac{dv}{dt} . m$

$\frac{dm}{dt}$ is a negative constant as the rocket is burning fuel.

m is decreasing so $\frac{dv}{dt}$ must be increasing in order to compensate.

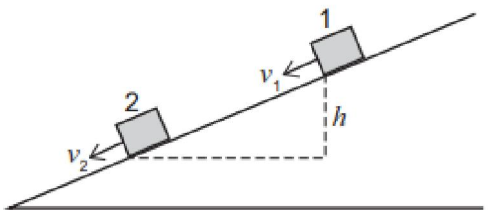
Answer is A

ENGAA S1 2020 - Question 21

21 A block of mass m slides down a rough slope.

At position 1 the velocity of the block is v_1.

At position 2, which is a vertical distance h below position 1, the velocity of the block is v_2.



Which expression gives the work done against friction by the block as it slides from position 1 to position 2?

(gravitational field strength = g; assume that air resistance is negligible)

A $mgh + \frac{1}{2}m(v_2{}^2 - v_1{}^2)$

B $mgh - \frac{1}{2}m(v_2{}^2 - v_1{}^2)$

C $mgh + \frac{1}{2}m(v_2 - v_1)^2$

D $mgh - \frac{1}{2}m(v_2 - v_1)^2$

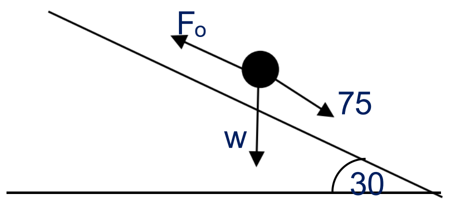
E $\frac{1}{2}m(v_2{}^2 - v_1{}^2) - mgh$

F $\frac{1}{2}m(v_1{}^2 - v_2{}^2) - mgh$

G $\frac{1}{2}m(v_2 - v_1)^2 - mgh$

H $\frac{1}{2}m(v_1 - v_2)^2 - mgh$

ENGAA S1 2020 - Question 21 - Worked Solution



$$E_1 = \frac{1}{2}mv_1{}^2 + mgh$$

$$E_2 = \frac{1}{2}mv_2{}^2$$

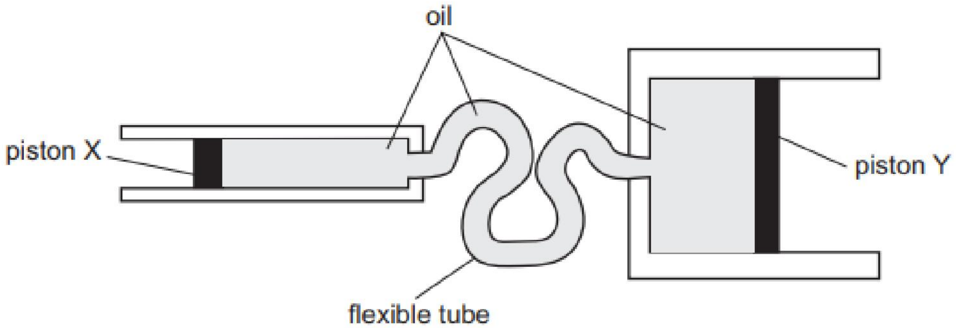
$$W = E_1 - E_2 = mgh + \frac{1}{2}m{v_1}^2 - \frac{1}{2}m{v_2}^2$$

$$W = mgh - \frac{1}{2}m({v_2}^2 - {v_1}^2)$$

Answer is B

ENGAA S1 2020 - Question 23

23 The braking system of a car includes two cylinders containing an incompressible oil, linked by a flexible tube that also contains oil. There is a freely moving piston in each cylinder. One piston is labelled X, and the other is labelled Y in the diagram.



When the driver presses on the brake pedal, a force is exerted on piston X. The pressure produced in the oil by this force is transmitted through the oil so that it causes a force to act on piston Y. This presses the brakes against the moving parts.

The diameter of piston X is 4.0 cm. The diameter of piston Y is 12.0 cm.

The driver exerts a force of 36.0 N on piston X and it moves a distance of 5.4 cm to the right.

What is the resultant force on piston Y and how far does it move along the cylinder?

	force on piston Y / N	*distance moved by piston Y* / cm
A	4.0	0.60
B	4.0	48.6
C	12.0	1.80
D	12.0	16.2
E	108	1.80
F	108	16.2
G	324	0.60
H	324	48.6

ENGAA S1 2020 - Question 23 - Worked Solution

$$length\ factor: \frac{y}{x} = \frac{12}{4} \rightarrow factor\ of\ 3$$

Area factor → l_2 → factor of 9

$$P = \frac{F}{A} \rightarrow F \propto A \rightarrow factor\ of\ 9$$

Thus 36N in piston x is 36 × 9N = 324N in piston y

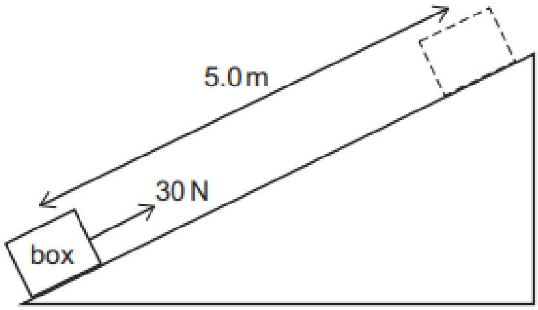
$P = \frac{F}{A}$ → Area increase, force decreased , lower piston distance

Answer is G

ENGAA S1 2020 - Question 29

29 A box of mass 3.0 kg is pulled a distance 5.0 m directly up a smooth slope by a constant applied force of 30 N acting parallel to the slope.

The initial speed of the box is $3.0\,\text{m s}^{-1}$ and the final speed is $7.0\,\text{m s}^{-1}$. Its acceleration is constant.



What is the component of the weight acting down the slope?

(gravitational field strength = $10\,\text{N kg}^{-1}$; air resistance is negligible)

A 12 N

B 18 N

C 22 N

D 28 N

E 29 N

F 42 N

G 90 N

ENGAA S1 2020 - Question 29 - Worked Solution

$$\Delta t = mgh + \frac{1}{2}mv^2 = F.d$$

$$30\text{N} \times 5\text{m} = 3 \times 10 \times 5 \sin\sin\theta + \frac{1}{2} \times 3 \times (7^2 - 3^2)$$

$$\sin\sin\theta = \frac{90}{150} = \frac{3}{5}$$

Weight acting down slope:

$$W^{l} = W \sin\sin @$$

$$W^{l} = 3\text{kg} \times 10 \times \sin\sin @$$

$$= 30 \times \frac{3}{5}$$

$$W' = 18N$$

Answer is B

ENGAA S1 2020 - Question 33

33 A tennis ball travelling at 24.0 m s^{-1} is hit by a racket. As a result of the impact, the ball returns back along its original path having undergone a change in velocity of 48.0 m s^{-1}. The acceleration of the ball whilst in contact with the racket is constant with magnitude 6000 m s^{-2}.

What is the total distance travelled by the ball whilst in contact with the racket?

A 0.00 cm

B 4.80 cm

C 9.60 cm

D 14.4 cm

E 19.2 cm

ENGAA S1 2020 - Question 33 - Worked Solution

$$u = 24$$

$$v = -24$$

$$a = -6000 ms^{-1}$$

$$\text{use } v^2 - u^2 = 2as$$

As this gives s = 0, since the ball is not a rigid body. To account for the compression of the ball, we may split it into two parts.

$$24^2 - 0^2 = 2(6000) . S_1$$

$$24^2 - 0^2 = 2(6000) . S_2$$

$$S_1 + S_2 = 2 \times \frac{24^2}{2 \times 6000} = 0.96m = 9.6m$$

Answer is C

ENGAA S1 2019 - Question 5

5 The resistance to the motion of a car is directly proportional to the square of the speed of the car.

The car increases its speed by 20%.

What is the percentage increase in the resistance to the motion of the car?

A 20%

B 24%

C 44%

D 120%

E 224%

F 240%

G 400%

ENGAA S1 2019 - Question 5 - Worked Solution

R IX V_2

$(12V)^2 = 1.44V_2$

R increases by 44%

Answer is C

ENGAA S1 2019 - Question 14

14 The kinetic energy of an object of mass 4.0 kg, travelling in a straight line, increases from 32 J to 200 J in 3.0 seconds due to a constant resultant force.

What is the value of this resultant force?

A 2.0 N

B 4.0 N

C 8.0 N

D 24 N

E 28 N

F 56 N

ENGAA S1 2019 - Question 14 - Worked Solution

$$T_0 = 32J = \frac{1}{2}m{v_0}^2 \rightarrow v_0 = 4$$

$$T_1 = 200J = \frac{1}{2}m{v_1}^2 \rightarrow v_1 = 10$$

By Newton's 2nd law:

$$F = ma = m\frac{v - u}{\Delta t} = 4.\frac{10 - 4}{3}$$

: F = 8N

Answer is C

ENGAA S1 2019 - Question 32

32 An astronaut on the Moon throws a ball vertically upwards. The ball has a mass of 2.0 g and is thrown upwards at $80\,\text{m s}^{-1}$.

What is the maximum height gained by the ball?

(gravitational field strength close to the Moon's surface = $1.6\,\text{N kg}^{-1}$)

A 25 m

B 50 m

C 320 m

D 2000 m

E 3200 m

F 4000 m

ENGAA S1 2019 - Question 32 - Worked Solution

$v^2 - u^2 = 2aS$

$$S = \frac{0^2 - 80^2}{-2 \cdot 1.6}$$

0 velocity at the apex

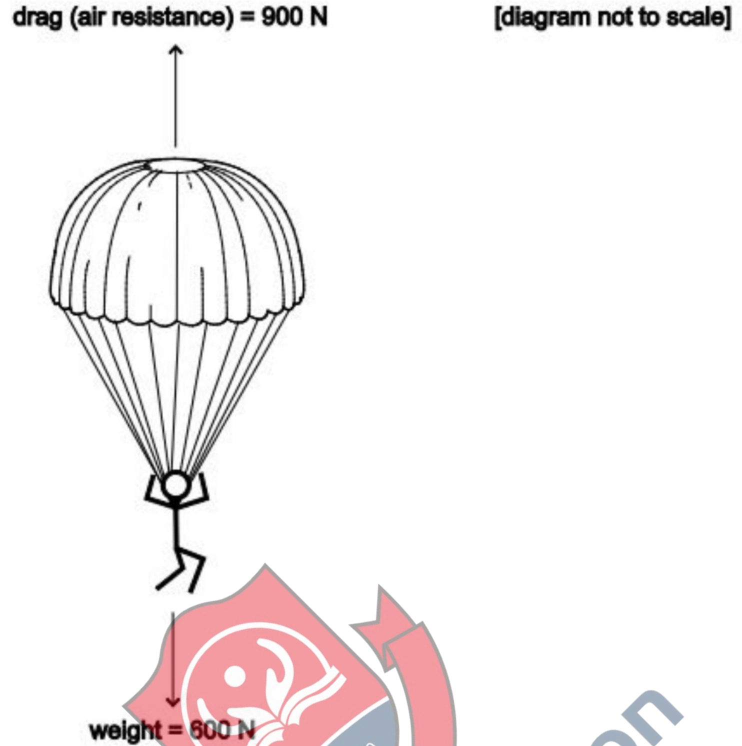
Hence $v^2 = 0$

$S = 2000\text{m}$

Answer is D

ENGAA Specimen S1 - Question 2

2 Shortly after opening her parachute, a free-fall parachutist of mass 60 kg (including equipment) experiences the forces shown in the diagram.



Which line in the table gives the size and direction of the acceleration of the parachutist at this instant?

	size of acceleration / $m\,s^{-2}$	*direction of acceleration*
A	5.0	downwards
B	10.0	downwards
C	5.0	upwards
D	10.0	upwards
E	0.0	—

ENGAA Specimen S1 - Question 2 - Worked Solution

$$\Sigma F = ma$$

$$900 - 600 = 60a$$

$$a = 5.0 ms^{-2} \text{ upwards}$$

Answer is C

ENGAA Specimen S1 - Question 10

10 A lorry of mass m, and travelling initially at speed v along a horizontal road, is brought to rest by an average horizontal braking force F in time t.

Ignoring any other resistive forces, what distance is travelled by the lorry during this time?

(gravitational field strength $= g$)

A $\frac{F}{mg}$

B $\frac{mgv}{F}$

C $\frac{mv^2}{2F}$

D $\frac{v^2}{2g}$

E vt

F $2vt$

ENGAA Specimen S1 - Question 10 - Worked Solution

$$F = ma \qquad a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{F}{m} = -\frac{v}{t}$$

$$s = vt - \frac{1}{2}at^2 \qquad \textit{one can use suvats}$$

Note that v in this equation is the final velocity and is equal to 0.

$$t = -\frac{vm}{F}$$

$$s = 0 - \frac{1}{2}\frac{F}{m}\left(\frac{-vm}{F}\right)^2$$

$$= -\frac{v^2 m}{2F}$$

distance = IsI

$$= \frac{mv^2}{2F}$$

Answer is C

ENGAA Specimen S1 - Question 22

22 Particle P has a fixed mass of 2 kg and particle Q has a fixed mass of 5 kg.

The two particles are moving in opposite directions along a straight line on a smooth plane.

Particle P has a speed of $3\,\mathrm{m\,s^{-1}}$ and particle Q has a speed of $r\,\mathrm{m\,s^{-1}}$.

The particles collide directly. After the collision the direction of each particle is reversed.

The speed of P is now $1\,\mathrm{m\,s^{-1}}$ and the speed of Q is halved.

What is the value of r?

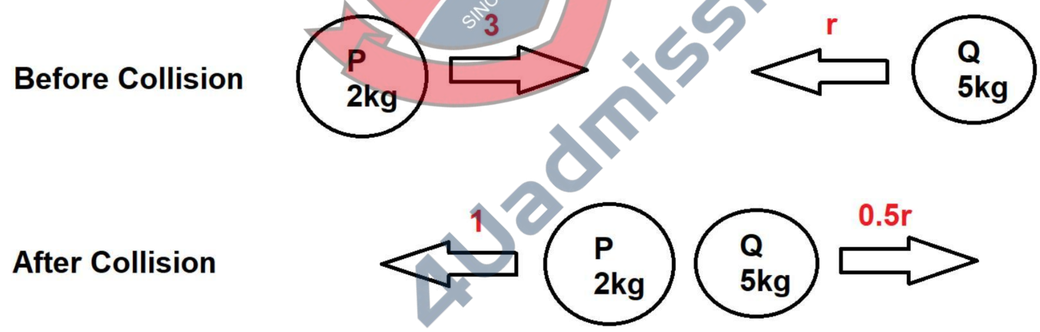
A $\frac{8}{15}$

B $\frac{14}{15}$

C $\frac{16}{15}$

D $\frac{8}{3}$

E $\frac{16}{5}$



ENGAA Specimen S1 - Question 22 - Worked Solution

Conservation of Momentum:

Total momentum before collision = Total momentum after collision

$$2 \times 3 + 5 \times (-r) = 2 \times (-1) + 5 \times (0.5r)$$

$$7.5r = 8$$

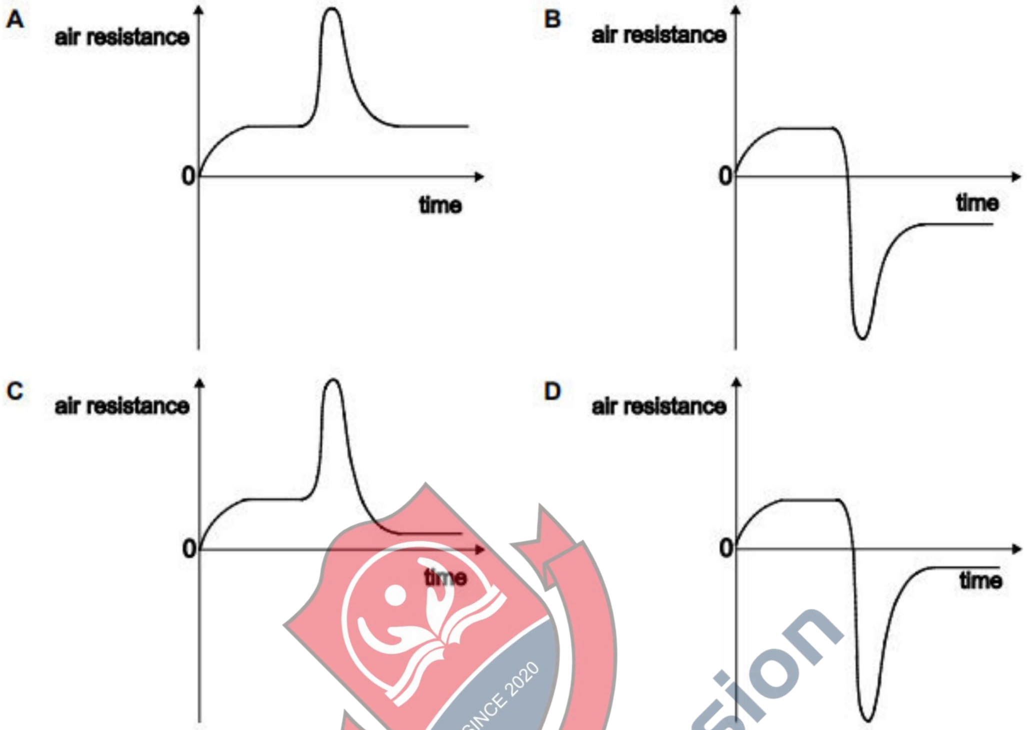
$$r = \frac{8}{7.5} = \frac{16}{15}$$

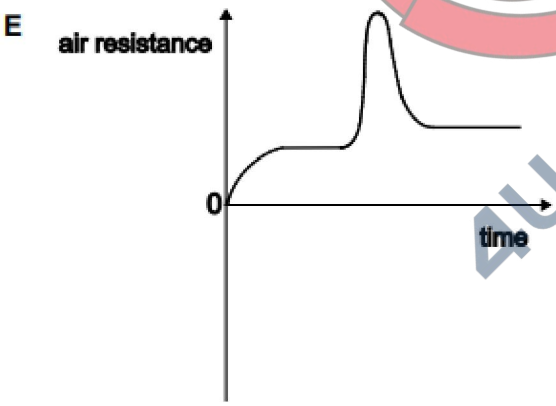
Answer is C

ENGAA Specimen S1 - Question 24

24 A parachutist falls from an aircraft and reaches a terminal velocity. After a while he opens his parachute and reaches a new (lower) terminal velocity.

Which graph shows how the total air resistance (drag) force acting on him and the parachute varies with time during the fall?





ENGAA Specimen S1 - Question 24 - Worked Solution

At terminal velocity air resistance = weight,

Therefore air resistance is same for both terminal velocities.

Answer is A

ENGAA Specimen S1 - Question 26

26 A heavy block of stone rests on a rough, horizontal surface.

The block is subject to a horizontal force that increases from zero at a constant rate.

Assume that the coefficient of friction is greater than zero and that its value is independent of whether or not the block is moving.

What happens to the block of stone?

(Assume air resistance is negligible.)

A It moves forwards immediately and accelerates forwards with a constant acceleration.

B It remains stationary at first and then accelerates forwards with a constant acceleration.

C It remains stationary at first and then accelerates forwards with an increasing acceleration.

D It moves forwards immediately with a constant velocity.

E It remains stationary at first and then moves forwards with a constant velocity.

ENGAA Specimen S1 - Question 26 - Worked Solution

The box remains stationary until the force can overcome friction

$$\Sigma F = ma$$

As F increases, a also increases

So the acceleration increases

Answer is C

ENGAA Specimen S1 - Question 28

28 A white billiard ball of mass 0.20 kg is travelling horizontally at $3.0\,m\,s^{-1}$ and hits a red billiard ball of the same mass which is at rest. After the collision the white ball continues in the same direction with a speed of $1.0\,m\,s^{-1}$.

What is the speed of the red ball immediately after the collision?

A $1.0\,m\,s^{-1}$

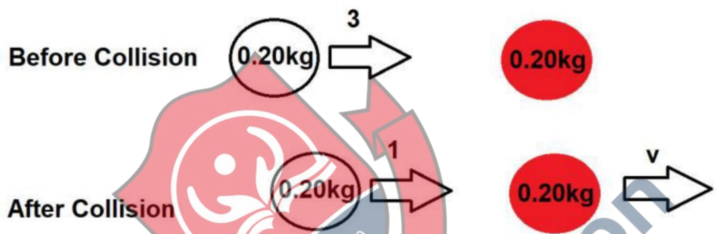
B $1.5\,m\,s^{-1}$

C $2.0\,m\,s^{-1}$

D $2.5\,m\,s^{-1}$

E $3.0\,m\,s^{-1}$

ENGAA Specimen S1 - Question 28 - Worked Solution



Conservation of momentum:

$$m \times 3 + m \times 0 = m \times 1 + m \times v$$

$$v = 2ms^{-1}$$

Answer is C

ENGAA Specimen S1 - Question 32

32 A man of weight 600 N stands on a set of accurate weighing scales in a moving elevator (lift). The reading on the scales is 480 N.

Which statement correctly describes the motion of the elevator?

A The elevator is moving downwards with constant speed.

B The elevator is moving downwards with decreasing speed.

C The elevator is moving upwards with increasing speed.

D The elevator is moving upwards with constant speed.

E The elevator is moving upwards with decreasing speed.

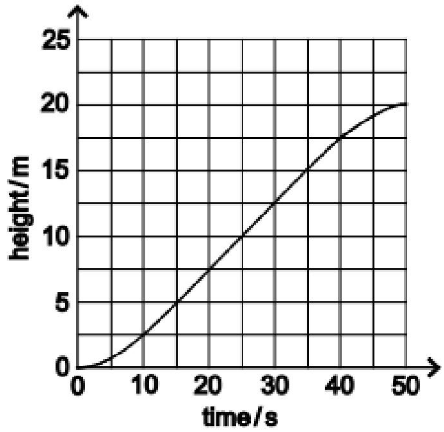
ENGAA Specimen S1 - Question 32 - Worked Solution

The elevator is accelerating downwards as the scales are exerting less than 600N reaction force on the man.
NB: This does not mean the elevator is moving downwards

Answer is E

ENGAA Specimen S1 - Question 38

38 The graph shows the variation with time of the height through which a crane lifts a mass of 20 kg.



What is the power output of the crane when the mass is at a height of 10 m?

(gravitational field strength = 10 N kg^{-1}, the effects of air resistance and friction are negligible)

A 0.1 W

B 10 W

C 40 W

D 100 W

E 400 W

F 4000 W

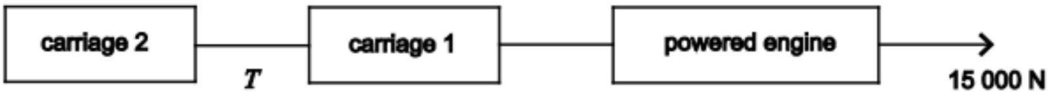
ENGAA Specimen S1 - Question 38 - Worked Solution

$$P = \frac{\Delta E}{\Delta t} = mg\frac{\Delta h}{\Delta t} = 20 \times 10 \times \frac{5}{10} = 100w$$

Answer is D

ENGAA Specimen S1 - Question 40

40 A train consists of a powered engine travelling horizontally pulling two unpowered carriages.



The engine has a mass of 20 000 kg, and each carriage has a mass of 5000 kg. When the engine accelerates from rest it develops a thrust (driving force) of 15 000 N as shown.

Ignoring resistive forces, what is the tension (pulling force) T in the light and inextensible coupling between carriage 1 and carriage 2?

A 2500 N

B 3750 N

C 5000 N

D 7500 N

E 15 000 N

ENGAA Specimen S1 - Question 40 - Worked Solution

$$\Sigma F = ma \text{ on the whole train}$$

$$15000 = (20000 + 5000 + 5000)a$$

$$a = \frac{15000}{30000} = 0.5ms^{-2}$$

Focusing on carriage 2

$$\Sigma F = ma$$

$$T = 5000 \times 0.5$$
$$T = 2500 \text{ N}$$

Answer is A

ENGAA S1 2018 - Question 12

12 The momentum of a small object moving in a straight line is 24 kg m s^{-1} and its kinetic energy is 96 J.

What is the mass of the object?

A 3.0 kg

B 4.0 kg

C 6.0 kg

D 8.0 kg

E 12 kg

ENGAA S1 2018 - Question 12 - Worked Solution

$$p = mv = 24 \quad (1)$$

$$k = \frac{1}{2}mv^2 = 96 \quad (2)$$

(1)→(2)

$$\frac{1}{2} \times 24 \times v = 96$$

$$v = 8$$

Sub into (1)

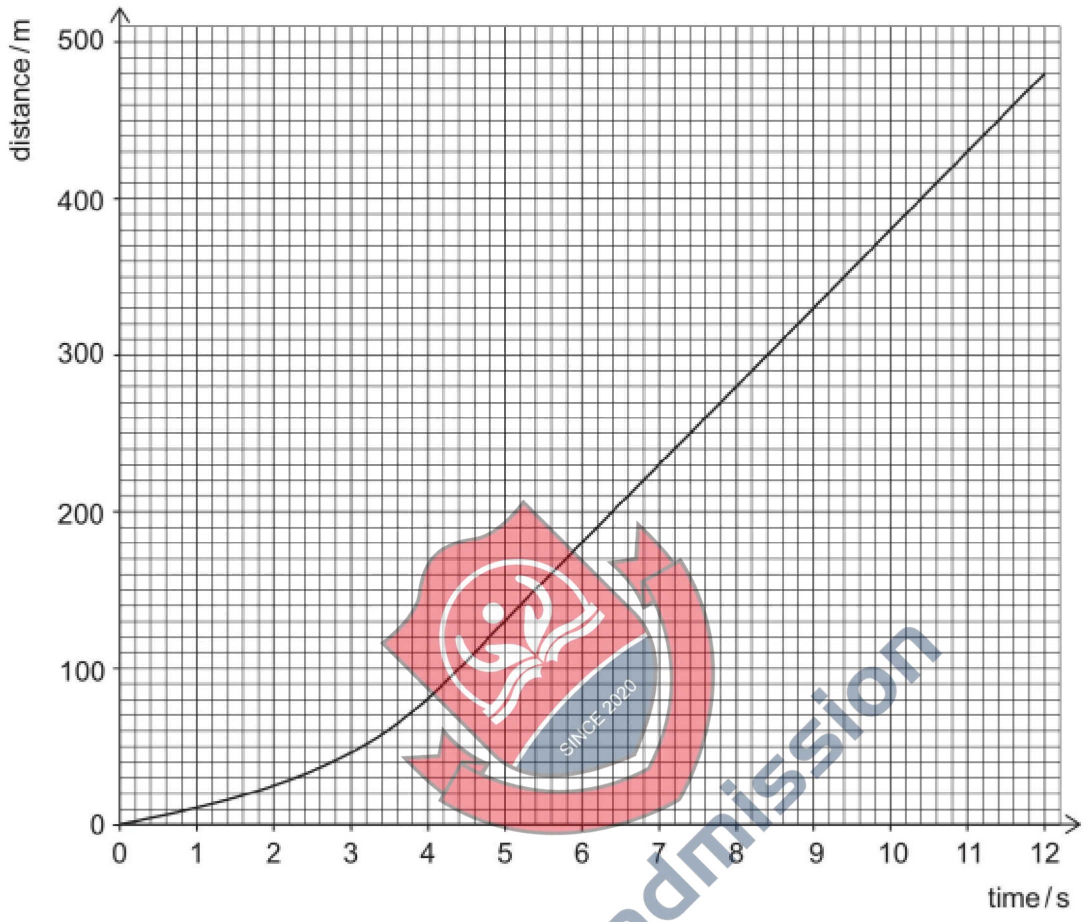
$$m = \frac{24}{8} = 3\ kg$$

Answer is A.

ENGAA S1 2018 - Question 22

22 A skydiver of weight 1000 N falls vertically.

The distance–time graph for the skydiver is shown below.



The air resistance F (in N) acting on the skydiver travelling at velocity v (in $\mathrm{m\,s^{-1}}$) is given by the equation

$$F = kv^2$$

where k (in $\mathrm{N\,m^{-2}\,s^2}$) is a constant.

What is the numerical value of k for the skydiver?

A 0.050

B 0.40

C 0.63

D 2.5

E 20

ENGAA S1 2018 - Question 22 - Worked Solution

When $w = kv^2$, skydiver reaches terminal velocity (constant)

$$k = \frac{w}{v^2}$$

From graph: v = gradient

$$v = \frac{\Delta v}{\Delta t}$$

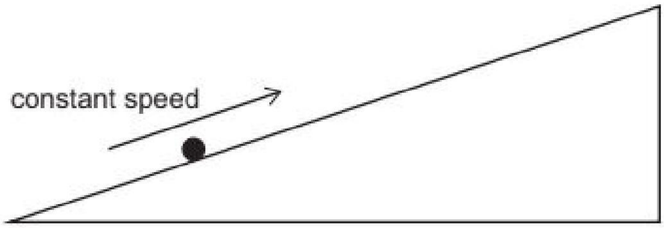
$$v = \frac{50}{1} = 50\, ms^{-1}$$

$$k = \frac{w}{v^2} = \frac{1000}{50^2} = 0.4$$

Answer is B.

ENGAA S1 2018 - Question 32

32 The diagram represents a mass that is moving in a straight line at constant speed up a slope of constant gradient.



Which statement about the forces acting on the mass **must** be correct?

A All the forces acting on the mass are equal in magnitude.

B Only three forces act on the mass.

C The force of friction on the mass is equal to the driving force.

D The weight of the mass acts in the opposite direction to the contact force.

E There is no air resistance acting on the mass.

F There is no resultant force acting on the mass.

ENGAA S1 2018 - Question 32 - Worked Solution

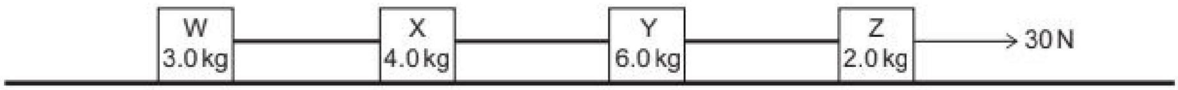
$F = ma = 0 \Rightarrow$ resultant force is 0
B , C, D → could be true, but don't have to be

Answer is F.

ENGAA S1 2018 - Question 34

34 The diagram shows four objects W, X, Y and Z, of masses 3.0 kg, 4.0 kg, 6.0 kg and 2.0 kg respectively, connected by light, inextensible rods.

The objects are pulled along a smooth, horizontal surface by a constant force of 30 N in the direction indicated.



What is the tension in the rod connecting X and Y?

A 8.0 N

B 10 N

C 12 N

D 14 N

E 16 N

ENGAA S1 2018 - Question 34 - Worked Solution

Rod is inextensible → all blocks have same acceleration : a

$$F = ma$$
$$30 = 15a$$
$$a = 2ms^{-1}$$

Now for Z

$$30 - T_1 = ma = 2 \times 2 = 4$$
$$T_1 = 26N$$

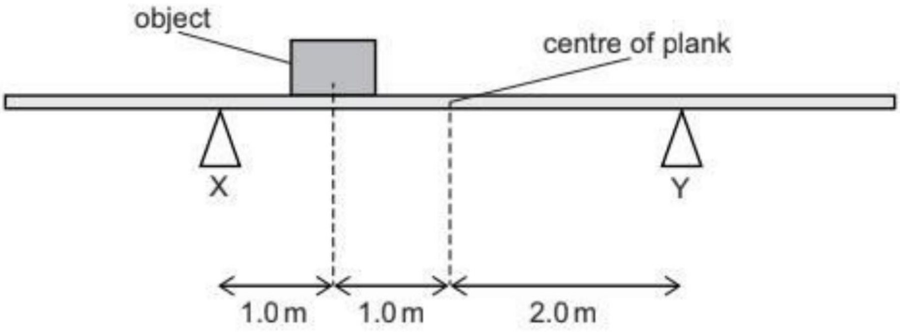
For Y

$$T_1 - T_2 = ma$$
$$26 - T_2 = 6 \times 2$$
$$T_2 = 14N$$

Answer is D.

ENGAA S1 2018 - Question 36

36 An object of mass 40 kg is placed on a uniform, horizontal plank of mass 10 kg between two supports X and Y as shown in the diagram.



What is the contact force at X?

(gravitational field strength = $10\,N\,kg^{-1}$)

A 15 N

B 35 N

C 150 N

D 250 N

E 300 N

F 350 N

G 375 N

ENGAA S1 2018 - Question 36 - Worked Solution

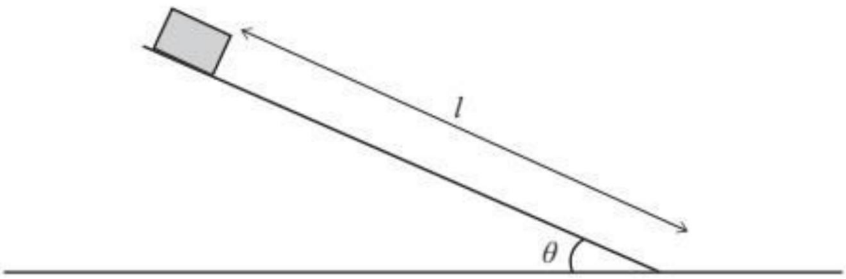
Reduce moments about Y:

$$R(1 + 1 + 2) - 40g(1 + 2) - 10g(2) = 0$$
$$4R - 140g = 0$$
$$R = 35g$$
$$R = 350\,N$$

Answer is F.

ENGAA S1 2018 - Question 38

38 A block of mass m slides a distance l down a slope that is inclined at angle θ to the horizontal, as shown:



The block experiences a friction force of $kW\sin\theta$, where W is the weight of the block and k is a constant.

The block starts from rest at the top of the slope and slides down a distance l to the bottom, where its potential energy is zero.

What fraction of the initial potential energy at the top has become kinetic energy as the block reaches the bottom?

A k

B $1 - k$

C $k\sin\theta$

D $1 - k\sin\theta$

E $k\tan\theta$

F $1 - k\tan\theta$

ENGAA S1 2018 - Question 38 - Worked Solution

ΔEP = mgh

= WL sin sin @

Work done by friction:

W=FL

= kW sin sin @ L

ΔEx = ΔEP —W = WL sin sin @ —kW sin sin @

= (1 —k)WL sin sin @

$$\frac{\Delta Ex}{\Delta Ep} = \frac{(1-k)WL\ sin\ sin\ \square}{WL\ sin\ sin\ \square} = 1 - k$$

Answer is B.

ENGAA S1 2018 - Question 40

40 An object X of mass 2.0 kg is initially moving at a speed of 4.5 m s^{-1} on a smooth, horizontal surface.

A 5.0 N force is applied to X in the direction of its motion for 3.0 seconds.

A short time later it collides head on with, and sticks to, a stationary object Y of mass 3.0 kg.

What is the speed of X and Y as they move off together after the collision?

A 1.8 m s^{-1}

B 3.0 m s^{-1}

C 3.6 m s^{-1}

D 4.8 m s^{-1}

E 5.4 m s^{-1}

ENGAA S1 2018 - Question 40 - Worked Solution

$\Delta P = F\Delta t$, $U = 4.5ms^{-1}$

$mv - mu = F\Delta t$

$2(V_x - 4.5) = 5 \times 3$

$V_x = 12ms^{-1}$

Conservation of momentum:

$M_x V_x = (M_x + M_t)V_{xt}$

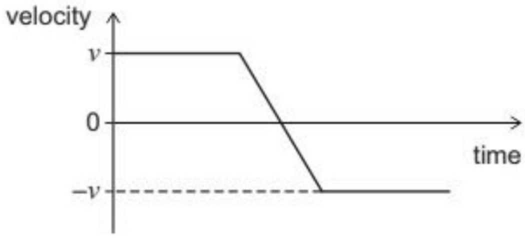
$$V_{xy} = \frac{2 \times V_x}{(2+3)} = \frac{2}{5} \times 12 = \times 4.8ms^{-1}$$

Answer is D.

ENGAA S1 2018 - Question 44

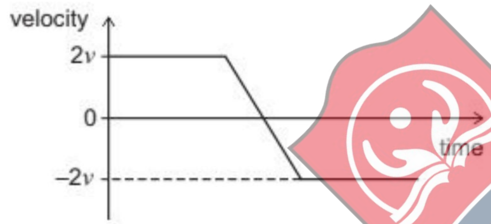
44 Two solid spheres X and Y have masses m and $2m$ respectively. They travel in opposite directions towards each other along the same line with speeds v and $2v$ respectively and collide head on.

The graph shows the variation of velocity with time for sphere X before, during, and after the collision.

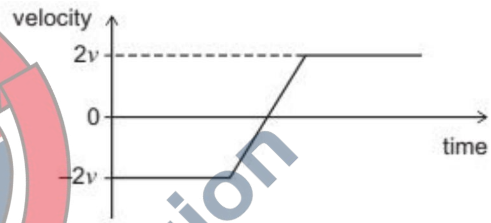


Which sketch shows the variation of velocity with time for sphere Y?

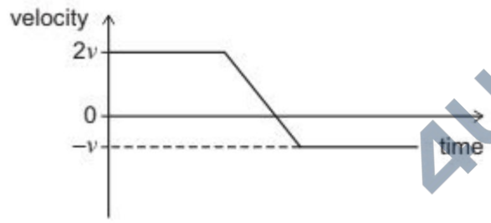
A



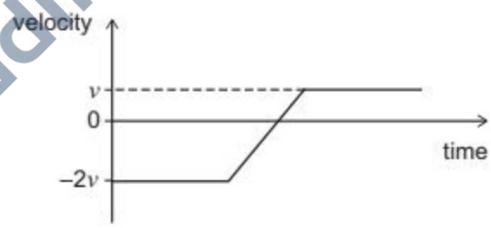
B



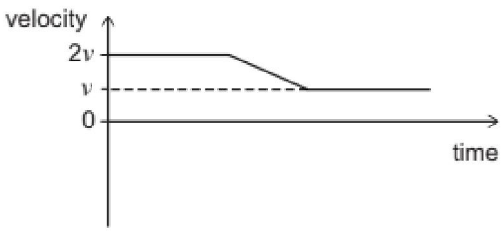
C



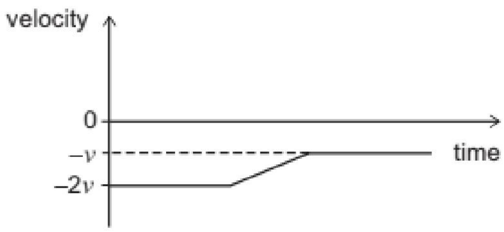
D



E



F



ENGAA S1 2018 - Question 44 - Worked Solution

So, at t = 0, Y has velocity -2v

After collision:

$V_x = -v$

(conserve momentum)

$$mv - 4vm = (-v)m + 2mv_t$$

$$2v_t = (1 - 4 + 1)v = -2v$$

$$v_t = -v$$

Answer is F.

ENGAA S1 2018 - Question 50

50 An object of mass m is initially moving at constant speed u to the right. It collides with a stationary object of greater mass M and bounces back in the opposite direction at speed v.

What is the speed of the greater mass immediately after the collision?

A $\frac{mu}{M}$

B $\frac{Mu}{m}$

C $\frac{m(v-u)}{M}$

D $\frac{M(v-u)}{m}$

E $\frac{m(v+u)}{M}$

F $\frac{M(v+u)}{m}$

ENGAA S1 2018 - Question 50 - Worked Solution

Conserve momentum:

MU = –VM + MV_m

$$\frac{M(U+V)}{M} = V_M$$

Answer is E.

ENGAA S1 2017 - Question 6

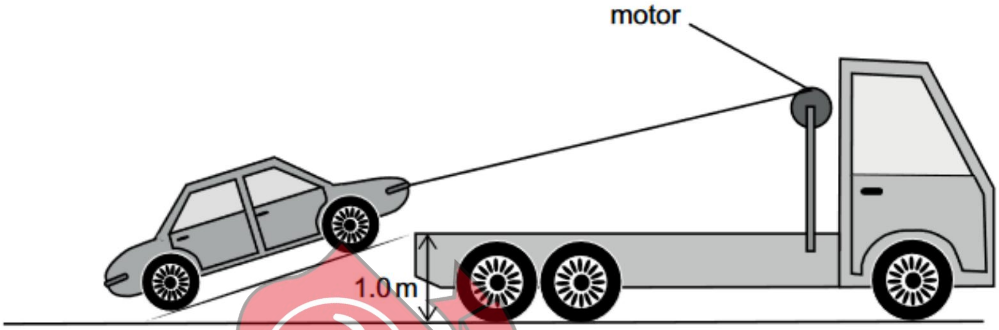
6 An electric motor is used to pull a broken-down car slowly from the road up a ramp on to the back of a breakdown truck.

The car has a mass of 1200 kg and is lifted through a vertical height of 1.0 m.

The total input energy to the motor is 28 kJ and it is 75% efficient.

In the process of lifting the car, energy is lost to the surroundings from the motor and from other causes.

What is the **total** energy lost to the surroundings?



(gravitational field strength = $10\,N\,kg^{-1}$)

A 7.0 kJ

B 9.0 kJ

C 12 kJ

D 16 kJ

E 21 kJ

F 33 kJ

ENGAA 2017 - Question 6 - Worked Solution

- Energy gained by car : (GPE)

$$mgh$$
$$= 1200 \times 10 \times 1$$
$$12000\,J$$

- Conservation at energy:

Input Energy = Energy lost + Energy gained by car

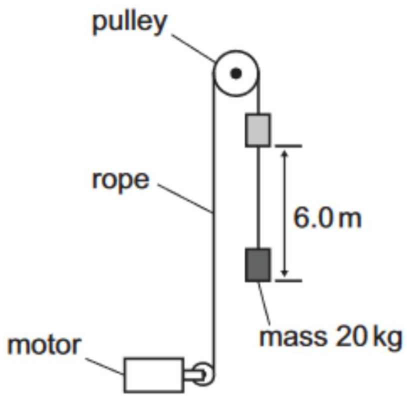
$$28000 = \text{Energy lost} + 12000$$
$$\text{Energy lost} = 16000J$$

Energy lost = 16KJ (include the energy lost due to the efficiency of the motor)

Answer is D

ENGAA S1 2017 - Question 12

12 An electric motor is connected to a constant 12 V d.c. supply. The motor is used to lift a mass of 20 kg by means of a rope and pulley. The mass is lifted vertically through a height of 6.0 m in a time of 5.0 s. The complete lifting system (motor, rope and pulley) is 80% efficient.



What is the current in the electric motor?

(gravitational field strength = $10\,\text{N kg}^{-1}$)

A 1.6 A

B 2.0 A

C 2.5 A

D 16 A

E 20 A

F 25 A

ENGAA 2017 - Question 12- Worked Solution

$$\Delta CPE = mgh = 20 \times 10 \times 6 = 1200\text{J}$$

$$\text{Efficiency} = \frac{Useful\ Energy}{Total\ Energy}$$

$$rp = \text{power}$$

$$rp = 1V$$

$$V = 12V$$

$$0.8 = \frac{\Delta CPE}{p \times \text{time}}$$

$$0.8 = \frac{1200}{1 \times 12 \times 5}$$

$$0.8 = \frac{16}{I}$$

$$I = \frac{16}{0.8}$$

$$I = 20\ A$$

Answer is E

ENGAA S1 2017 - Question 22

22 A freight train travelling on a straight horizontal track at $2.0\,m\,s^{-1}$ collides with a passenger train travelling at $5.0\,m\,s^{-1}$ in the opposite direction. Both trains immediately come to a complete stop on the track.

The freight train has three locomotives of 130 tonnes each and seven container wagons of 30 tonnes each. The passenger train has two locomotives of 70 tonnes each and a number of passenger carriages of 10 tonnes each.

How many passenger carriages does the passenger train have?

A 7

B 9

C 10

D 24

E 46

ENGAA 2017 - Question 22 - Worked Solution

$$M_t = 3 \times 130 + 7 \times 30 = 600$$

$$M_p = 2 \times 70 + 10N = 140 + 10N$$

Conserve momentum:

$$2M_t - 5M_p = 0$$

$$\Rightarrow M_p = \frac{2M_t}{5}$$

$$\Rightarrow 140 + 10N = \frac{2}{5} \times 600 = 240$$

$$\rightarrow 10N = 100$$

$$\rightarrow N = 10$$

Answer is C

ENGAA S1 2017 - Question 24

24 Consider the following three statements about a parachutist of mass 72 kg falling vertically at a constant velocity of 5.0 $m\,s^{-1}$ after the parachute has opened:

1 The parachutist has a constant kinetic energy of 1800 J.

2 The parachutist is losing gravitational potential energy at a rate of 3600 $J\,s^{-1}$.

3 Air resistance and the force of gravity acting on the parachutist are a Newton's third law pair of forces.

Which of the statements is/are correct?

(gravitational field strength = 10 $N\,kg^{-1}$)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

ENGAA S1 2017 - Question 24 - Worked Solution

1)

$$Ex = \frac{1}{2}mv^2$$

$$Ex = \frac{1}{2} \times 72 \times 5^2 = 900J$$

So False

2)

$$\frac{dE}{dt} = \frac{d}{dt}(mgh)$$

$$= mgh\frac{dh}{dt}$$

$$= mgv$$

$$= 72 \times 10 \times 5$$

$$3600\,Js^{-1}$$

So True

3)

The two forces act on the same body (parachutist) , so false.

Answer is C

ENGAA S1 2017 - Question 28

28 Car X passes car Y on a motorway.

Car X is travelling at 1.5 times the speed of car Y.

The mass of car X is $\frac{4}{5}$ of the mass of car Y.

How do the kinetic energies of the two cars compare?

A kinetic energy of car X = 0.90 × kinetic energy of car Y

B kinetic energy of car X = 0.96 × kinetic energy of car Y

C kinetic energy of car X = 1.20 × kinetic energy of car Y

D kinetic energy of car X = 1.44 × kinetic energy of car Y

E kinetic energy of car X = 1.80 × kinetic energy of car Y

ENGAA S1 2017 - Question 28 - Worked Solution

$$V_X = 1.5V_y$$

$$M_X = \frac{4}{5}M_Y$$

$$E_Y = \frac{1}{2}M_Y V_Y$$

$$E_X = \frac{1}{2}M_X V_X 2$$

$$= \frac{1}{2} \times \left(\frac{4}{5}M_y\right) \times \left(\frac{3}{2}V_X\right)^2$$

$$= 1.8 \times \frac{1}{2}M_X M_y$$

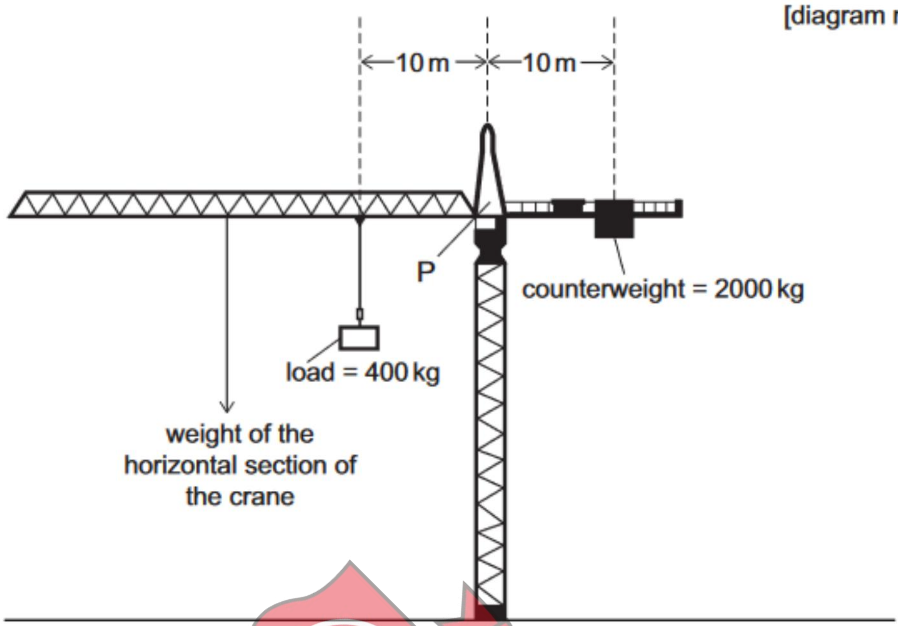
$$= 1.8E_y$$

Answer is E

ENGAA S1 2017 - Question 30

30 The diagram shows a crane being used on a building site. The crane is perfectly balanced about P.

[diagram not to scale]



The load is now moved to the left by 5.0 m.

To keep the crane perfectly balanced about P, how far does the counterweight have to move, and in which direction?

(gravitational field strength = $10\,N\,kg^{-1}$)

A 1.0 m to the left

B 1.0 m to the right

C 3.0 m to the left

D 3.0 m to the right

E 4.0 m to the left

F 4.0 m to the right

ENGAA S1 2017 - Question 30 - Worked Solution

- External torque

$$T = 400g \times 5$$
$$= 400 \times 10 \times 5$$
$$= 20000\ Nm$$

- So need an clockwise torque to balance so need to move counterweight by Δx to the right

$$T = 2000\,ug \times \Delta x$$
$$20000 = 2000 \times 10 \times \Delta x$$
$$\Delta x = 1m$$

Answer is B

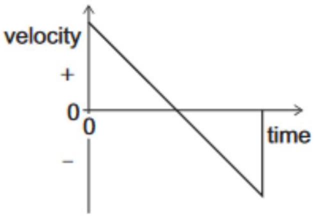
ENGAA S1 2017 - Question 32

32 A ball is thrown vertically upwards in still air and is then caught at the same height when it comes back down.

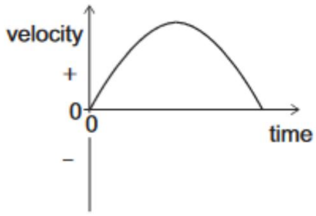
Which velocity–time graph shows this complete motion?

(Take upwards as positive, and ignore air resistance.)

A



B



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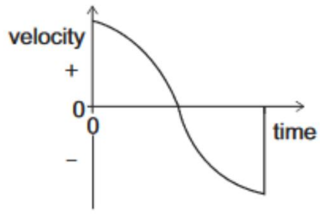
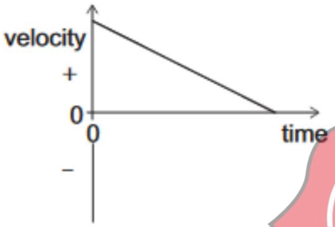
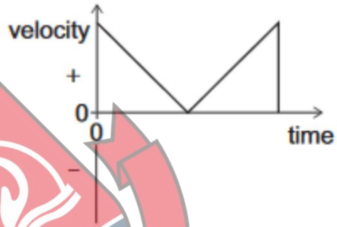


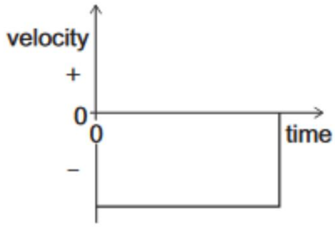
D



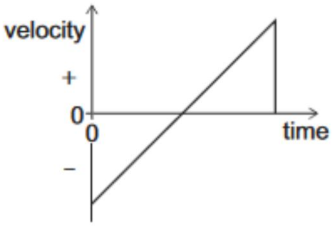
E



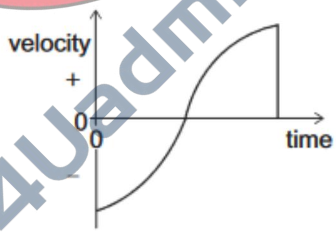
F



G



H



ENGAA S1 2017 - Question 32 - Worked Solution

- a = g, and constant → gradient is constant
- when ball falls back down, velocity is negative
- ball is thrown up, so initially velocity is positive

Answer is A

ENGAA S1 2017 - Question 34

34 An aircraft is climbing at constant speed in a straight line at an angle of 10° to the horizontal.

Which statement about the resultant force on the aircraft is correct?

A It is parallel to its motion.

B It is perpendicular to its motion.

C It is zero.

D It is equal to its weight.

E It is equal to the drag acting on the aircraft.

ENGAA S1 2017 - Question 34 - Worked Solution

- Speed is constant
- So acceleration is 0
- F = ma , so resultant force is 0

Answer is C

ENGAA S1 2017 - Question 36

36 A horizontal, uniform bar of mass 60 kg is 4.0 m long and is pivoted at one end. The bar is held in equilibrium by a force F at the other end of the bar, acting at an angle of 60° to the horizontal.

[diagram not to scale]

Which expression gives the magnitude of F in newtons?

(gravitational field strength = $10\,\text{N kg}^{-1}$)

A $\dfrac{30}{\sin 60^\circ}$

B $\dfrac{30}{\cos 60^\circ}$

C $\dfrac{60}{\sin 60^\circ}$

D $\dfrac{60}{\cos 60^\circ}$

E $\dfrac{300}{\sin 60^\circ}$

F $\dfrac{300}{\cos 60^\circ}$

G $\dfrac{600}{\sin 60^\circ}$

H $\dfrac{600}{\cos 60^\circ}$

ENGAA S1 2017 - Question 36 - Worked Solution

- Moment = Perpendicular x distance
- Resolve moments about pivot

$$2 \times 60\,g = F \sin\sin(60) \times 4$$

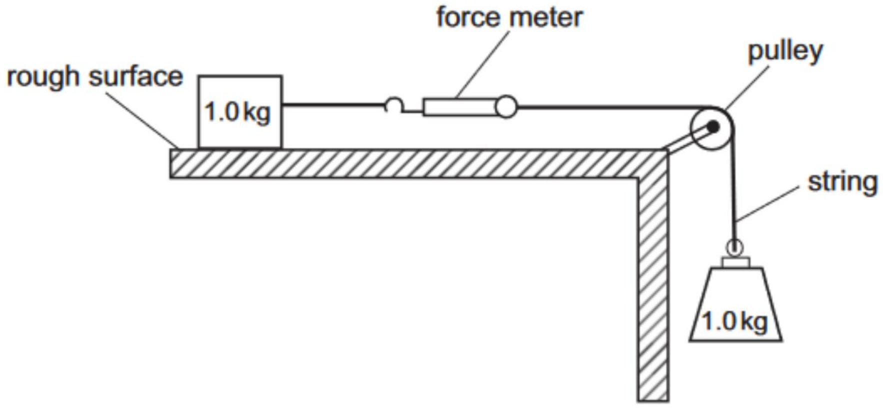
$$F = \frac{2 \times 60 \times 10}{\sin\sin(60) \times 4}$$

$$= \frac{300}{\sin\sin(60)}$$

Answer is E

ENGAA S1 2017 - Question 40

40 A block of mass 1.0 kg is at rest on a rough horizontal surface. The block is attached by a light inextensible string to a force meter. The other end of the force meter is attached by another light inextensible string via a frictionless pulley to a load of mass 1.0 kg. The block remains stationary.



What is the reading on the force meter?

(gravitational field strength = $10\,N\,kg^{-1}$)

A 0.0 N

B 0.5 N

C 1.0 N

D 2.0 N

E 5.0 N

F 10 N

G 20 N

ENGAA S1 2017 - Question 40 - Worked Solution

- String is inextensible and pulley is smooth
  →tension is uniform
- Resolve forces on load:
  T = mg
  → T = 1 x 10 = 10N
- So reading on force meter is 10N

Answer is F

ENGAA S1 2017 - Question 42

42 An apple of mass 100 g, growing on a tree, falls vertically from a height of 4.0 m above the ground. It hits the ground with a speed of 8.0 m s^{-1}.

How much work does the apple do against resistive forces during its descent, before it hits the ground?

(gravitational field strength = 10 N kg^{-1})

A 0.80 J

B 3.6 J

C 4.0 J

D 7.2 J

E 8.0 J

ENGAA S1 2017 - Question 42 - Worked Solution

$$\Delta EP = mgh = 0.1 \times 10 \times 4 = 4\,J$$

$$\Delta Ex = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.1 \times 8^2 = 3.2\,J$$

Then work done against resistance is :

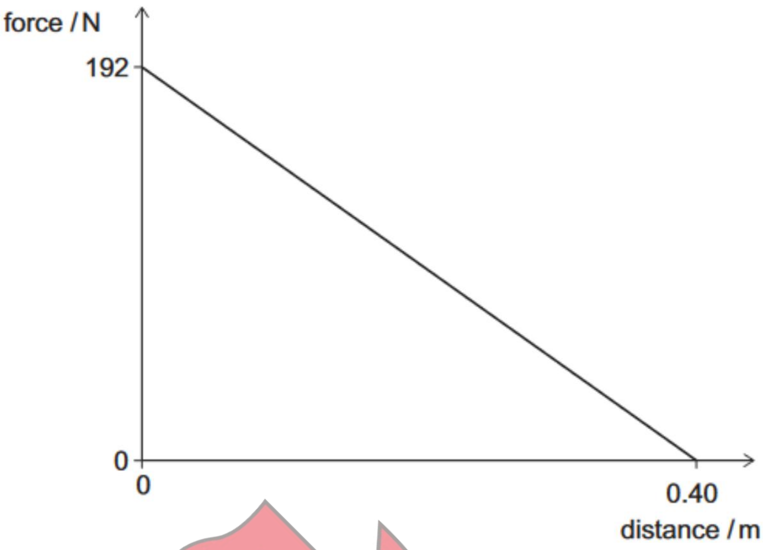
$$W = \Delta Ex - \Delta EP = 4 - 3.2 = 0.8\,J$$

Answer is A

ENGAA S1 2017 - Question 46

46 An archer fires an arrow of mass 0.024 kg vertically upwards from a bow.

The graph shows how the force of the bowstring on the arrow varies with distance as the arrow moves upwards.



The work done by the force of the bowstring is given by the area under the force-distance graph.

When the arrow leaves the bow, what is the kinetic energy of the arrow, and what is the maximum height that it gains from this point?

(Air resistance can be ignored. The effect of gravity as the arrow is fired is negligible compared to the force of the bowstring. The gravitational field strength = 10 N kg^{-1}.)

	kinetic energy / J	*height* / m
A	38.4	16
B	38.4	160
C	38.4	1600
D	38.4	16 000
E	76.8	32
F	76.8	320
G	76.8	3200
H	76.8	32 000

ENGAA S1 2017 - Question 46 - Worked Solution

W = Area

$$= \frac{1}{2} \times 0.4 \times 192$$

= 38.4J

= Initial kinetic energy

At max height, 100w is at rest, so

ΔEP = ΔEx

$$mgh = \frac{1}{2}mv^2$$

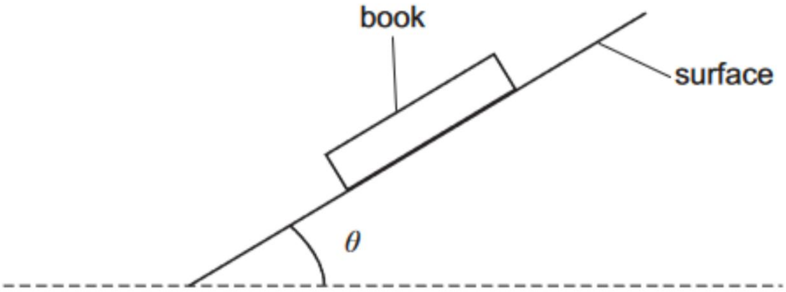
$$h = \frac{38.4}{0.024 \times 10}$$

= 160m

Answer is B

ENGAA S1 2017 - Question 48

48 A book of mass m rests on a rough horizontal surface. The surface is now tilted as shown:



When the angle of tilt θ is 20°, the book slides down the slope at a constant speed.

What is the acceleration of the book down the slope when the angle of tilt is 25°?

(gravitational field strength = g)

A $g\,(\cos 20° - \sin 20° \tan 5°)$

B $g\,(\cos 20° - \sin 20° \tan 25°)$

C $g\,(\cos 25° - \sin 5° \tan 20°)$

D $g\,(\cos 25° - \sin 25° \tan 20°)$

E $g\,(\sin 20° - \cos 20° \tan 5°)$

F $g\,(\sin 20° - \cos 20° \tan 25°)$

G $g\,(\sin 25° - \cos 5° \tan 20°)$

H $g\,(\sin 25° - \cos 25° \tan 20°)$

ENGAA S1 2017 - Question 48 - Worked Solution

when θ = 20∘

Resolving ꓲ to slope:

N = mg COs COs (20)

Resolving ll to slope:

mg sin sin (20) —F = 0

mg sin sin (20) = μN

mg sin sin (20) = μmg COs COs (20)

μ =tan tan (20)

when θ = 25∘

Resolving $\perp$ to slope:

$$N = mg \,Cos\, Cos\, (25)$$

Resolving II to slope:

$$F = ma$$

$$mg \sin \sin (25) - \mu(mg\, Cos\, Cos\, 25) = ma$$

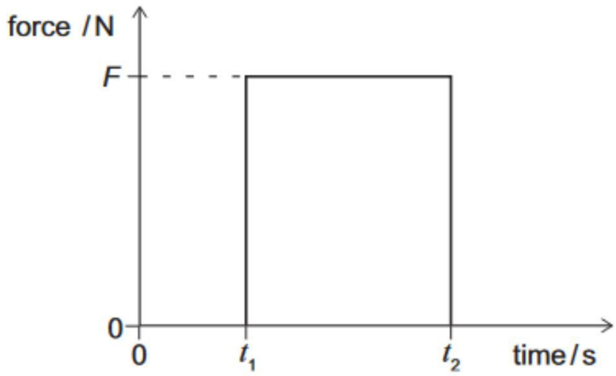
$$g \sin \sin (25) - g\mu\, Cos\, Cos\, (25) = a$$

$$g[\sin \sin (25) - \tan \tan (20)\, Cos\, Cos\, (25)] = a$$

Answer is H

ENGAA S1 2017 - Question 52

52 The graph shows how the horizontal force on a tennis ball of mass m varies during a shot in a tennis match. The ball is initially travelling horizontally toward the racket with speed u and leaves the racket horizontally travelling in the opposite direction with speed v.



Which expression gives the magnitude of the momentum of the ball as it leaves the racket?

A $F(t_2 - t_1)$

B $F(t_2 - t_1) - mu$

C $F(t_2 - t_1) + mu$

D $mv - mu$

E $Ft_2 - mu$

ENGAA S1 2017 - Question 52 - Worked Solution

$$F = \frac{dp}{dt} \Rightarrow \Delta p = \int F dt$$

$$= F(t_2 - t_1)$$

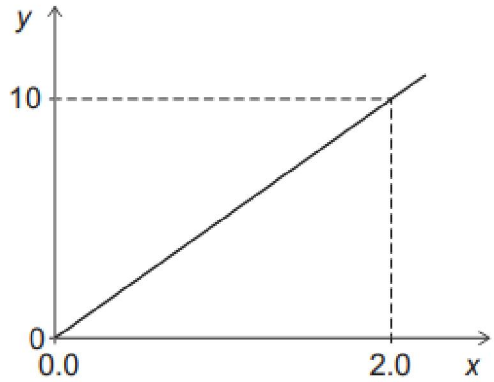
$$\Delta p = mv - m(-u) = F(t_2 - t_1)$$

$$mv = F(t_2 - t_1) - mu$$

Answer is B

ENGAA S1 2016 - Question 4

The graph shown of quantity *y* against quantity *x* represents the motion of a body.



(The scales on both axes are in the appropriate S.I. units, and the gravitational field strength *g* is 10 N kg^{-1}.)

Which two of the following could the graph represent?

1 kinetic energy against velocity for an object of mass 10 kg undergoing free-fall

2 potential energy against height for an object of mass 20 kg being lifted by a constant external force

3 velocity against time for an object of mass 20 kg being accelerated by a resultant force of 100 N

4 work done by an external force of 5 N against distance moved for an object of mass 12 kg being moved at constant speed by (and in the direction of) the external force

A 1 and 2

B 1 and 3

C 1 and 4

D 2 and 3

E 2 and 4

F 3 and 4

ENGAA S1 2016 - Question 4 - Worked Solution

1)

kinetic energy IX velocity^2

So 1 can't be true

2)

Potential energy = mgh

If the x-axis were height the gradient would be $mg = 20 \times 10 = 200$.

The gradient is 5 so 2 can't be true.

3)

F=ma a=change in velocity/change in time

If the force is constant 100N and the mass 20kg the gradient will be 5 , so 3 can be true.

4)

Work done = force x distance (does not depend on moon)

If force is 5N , the gradient will be 5

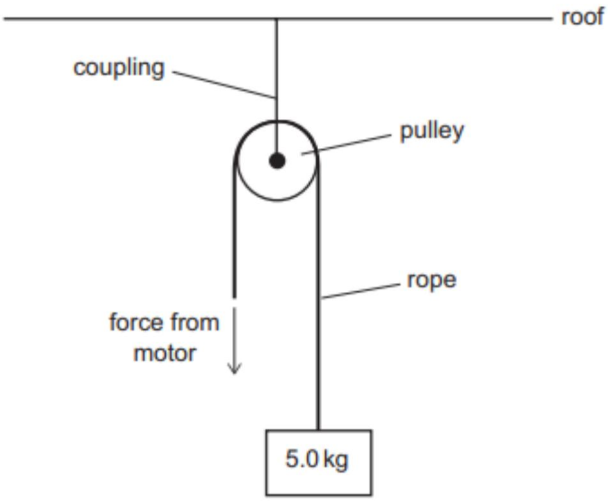
So 4 could be true.

3 & 4

Answer is F

ENGAA S1 2016 - Question 14

14 A motor is used to lift a mass of 5.0 kg using a pulley system as shown in the diagram. The pulley is secured to the roof using a coupling.



The motor needs to cause the mass to accelerate upwards at $0.80\,\text{m s}^{-2}$.

What is the minimum tension force that the coupling must be able to withstand without breaking?

(The gravitational field strength g is $10\,\text{N kg}^{-1}$. The pulley system is frictionless and has negligible mass. The rope has negligible mass and is inextensible.)

A 4.0 N

B 8.0 N

C 46 N

D 50 N

E 54 N

F 92 N

G 104 N

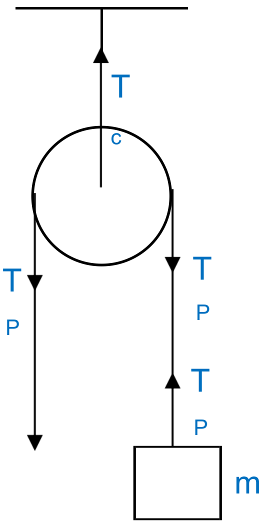
H 108 N

ENGAA S1 2016 - Question 14 - Worked Solution

$g = 10$

$m = 5.0\text{kg}$

$$a = 0.8ms^{-1}$$
$$T_p - mg = ma$$
$$T_p - 50 = 4.0$$
$$T_p = 54N$$
$$T_c = 2T_p$$



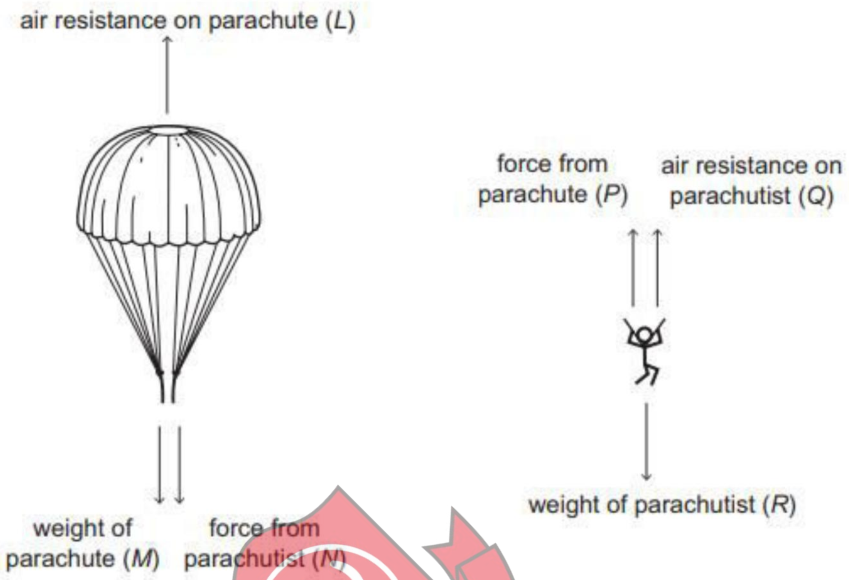
The coupling must be able to with stand at least 108N

Answer is H

ENGAA S1 2016 - Question 30

30 A parachutist is falling at terminal speed with his parachute open. The diagrams show, separately, the vertical forces acting on the parachute and the vertical forces acting on the parachutist.

The letters *L*, *M*, *N*, *P*, *Q* and *R* represent the magnitude of each force as indicated.



Consider the following equations:

Equation 1:	$L = M + N$
Equation 2:	$R = P + Q$
Equation 3:	$L = Q$
Equation 4:	$N = P$
Equation 5:	$M + R = L + Q$

Which of these equations, if any, is/are the direct result of the application of Newton's Third Law to this situation?

A none of them

B 3 only

C 4 only

D 5 only

E 1 and 2 only

F 3 and 4 only

G 1, 2 and 5 only

H 1, 2, 3, 4 and 5

ENGAA S1 2016 - Question 30 - Worked Solution

1 is a result of $= ma$, Newton's second law

2 is a result of $\Sigma F = ma$

3 states that the air resistance force is equal for the parachute and parachutist.

4 states that the force from the parachute on the parachutist is equal to the force from the parachutist on the parachute, which is Newton’s third law.

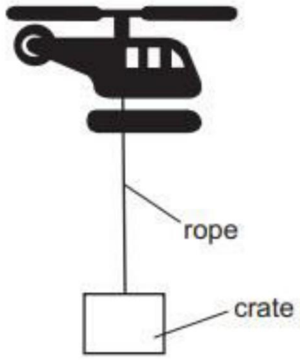
S is a result of $\Sigma F = ma$

Only 4 is a direct result of the application of Newton’s third law.

Answer is C

ENGAA S1 2016 - Question 32

32 A crate has a total mass of 800 kg, including its contents. A helicopter of mass 4200 kg is carrying the crate using a light inextensible rope as shown:



The helicopter and crate are accelerating upwards at $2.0\,m\,s^{-2}$.

What is the tension in the rope?

(The gravitational field strength g is $10\,N\,kg^{-1}$; air resistance can be ignored.)

A 6400 N

B 8000 N

C 9600 N

D 18 000 N

E 40 000 N

F 42 000 N

G 50 000 N

H 60 000 N

ENGAA S1 2016 - Question 32 - Worked Solution

$$T - mg = ma$$
$$T = 800 \times 10 + 800 \times 2$$
$$T = 9600N$$

Answer is C

ENGAA S1 2016 - Question 34

34 A shopper pushes a supermarket trolley a distance of 15 m in a straight line across a level, horizontal surface. The shopper applies a constant force of 50 N at an angle of 37° below the horizontal. The total weight of the trolley and its contents is 350 N.

[diagram not to scale]

What is the magnitude of the total vertical force that the surface exerts on the trolley and how much work is done by the pushing force?

(You may use the approximations $\sin 37° = 0.60$; $\cos 37° = 0.80$.)

	vertical force / N	*work done* / J
A	380	600
B	380	750
C	390	450
D	390	750
E	400	450
F	400	600

ENGAA S1 2016 - Question 34 - Worked Solution

$$W = Fd\ COS\ COS\theta$$

$$W = 15 \times 50 \times 0.80 = 600J$$

The vertical component of the force = 50 sin 37 = 30N

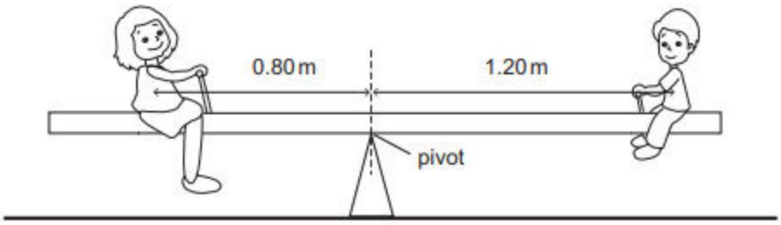
The total downward force on the trolley = 380N

Thus the reaction force of the surface on the trolley = 380N

Answer is A

ENGAA S1 2016 - Question 36

36 A plank of non-uniform density which has a mass of 15 kg is used to make a see-saw. A pivot is placed under the centre of the plank as shown on the diagram.



[diagram not to scale]

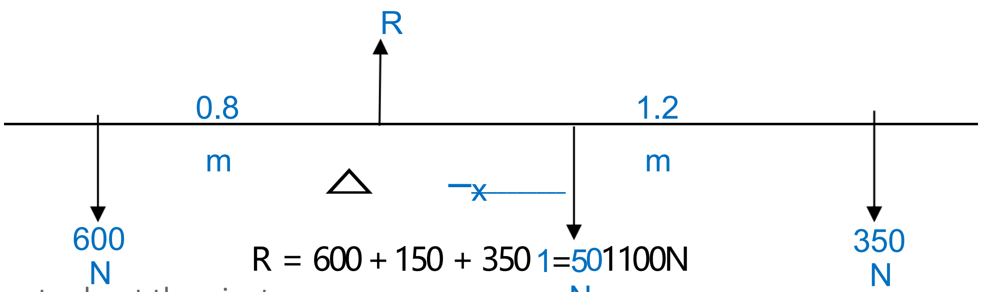
A boy of mass 35 kg sits at one end of the plank with his centre of gravity 1.20 m from the pivot. The see-saw balances when a woman of mass 60 kg sits on the plank on the other side of the pivot. Her centre of gravity is 0.80 m from the pivot.

Where is the centre of gravity of the plank and what is the magnitude of the force between the pivot and the plank?

(The gravitational field strength g is $10\,\mathrm{N\,kg^{-1}}$.)

	distance from pivot	*force* / N
A	0.40 m on left of pivot	100
B	0.40 m on left of pivot	1100
C	at the pivot	100
D	at the pivot	1100
E	0.20 m on right of pivot	100
F	0.20 m on right of pivot	1100
G	0.40 m on right of pivot	100
H	0.40 m on right of pivot	1100

ENGAA S1 2016 - Question 36 - Worked Solution



$R = 600 + 150 + 350 = 1100\,\mathrm{N}$

Take moments about the pivot

$$0.8 \times 600 = 1.2 \times 350 + x \times 150$$

$$480 = 420 + 150x$$
$$x = 0.4m$$

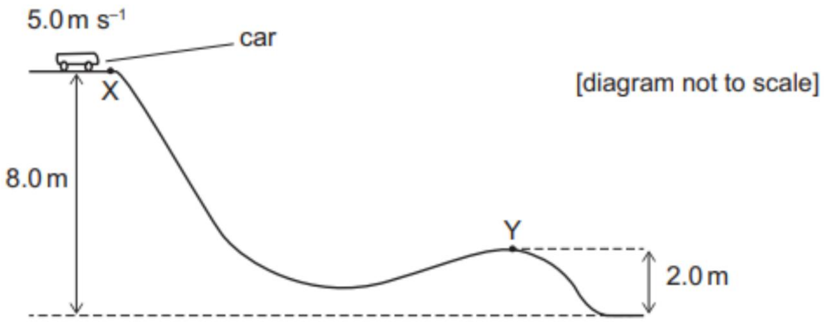
The center of gravity of the beam is 0.4m to the right of the pivot

NB : If CoG were to the left , x would have been negative.

Answer is H

ENGAA S1 2016 - Question 38

38 A car of mass 200 kg on a fairground ride travels at a speed of $5.0\,\text{m s}^{-1}$ at point X. The car is allowed to move down a sloping section of track without any energy input. The heights above the ground of points X and Y are shown. When the car reaches point Y its speed is $9.0\,\text{m s}^{-1}$.



How much energy is transferred in overcoming resistive forces as the car travels from X to Y?

(The gravitational field strength g is $10\,\text{N kg}^{-1}$.)

A 3900 J

B 6400 J

C 7900 J

D 10 400 J

E 11 200 J

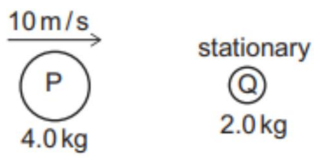
ENGAA S1 2016 - Question 38 - Worked Solution

$$\Delta GPE_{xy} = mg\Delta h$$
$$= 200 \times 10 \times 6$$
$$= 12000\text{J}$$
$$\Delta EK_{XY} = \frac{1}{2} \times 200 \times (9^2 - 5^2)$$
$$= 5600\text{J}$$
$12000 - 5600 = 6400\text{J}$ are lost to resistive forces

Answer is B

ENGAA S1 2016 - Question 46

46 The diagram shows a ball P, of mass 4.0 kg, moving to the right at 10 m s^{-1} directly towards a stationary ball Q, of mass 2.0 kg.



The balls collide but do not join together. Immediately after the collision ball Q moves at 10 m s^{-1} to the right.

What is the velocity of ball P immediately after the collision, and how much kinetic energy in total is lost during the collision?

	velocity of ball P after collision	*kinetic energy lost during collision / J*
A	0	50
B	0	150
C	10 m s^{-1} to the left	50
D	10 m s^{-1} to the left	150
E	5.0 m s^{-1} to the right	50
F	5.0 m s^{-1} to the right	150

ENGAA S1 2016 - Question 46 - Worked Solution

Conservation of momentum
Take going to the right as positive

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$4 \times 10 + 2 \times 0 = 4 \times v_1 + 2 \times 10$$

$$v_1 = +5.0\text{ms}^{-1}$$

$$\text{kinetic energy before} = \frac{1}{2} \times 4 \times 10^2 = 200\text{J}$$

$$\text{kinetic energy after} = \frac{1}{2} \times 4 \times 5^2 + \frac{1}{2} \times 2 \times 10^2 = 150\text{J}$$

$$\Delta E = 50\text{J}$$

Answer is E

ENGAA S1 2016 - Question 48

48 A point object of mass 2.0 kg is at rest on a level, horizontal surface. The coefficient of friction between the object and the surface is 0.25.

Two horizontal forces at right-angles to each other, with magnitudes 9.0 N and 12.0 N, are applied simultaneously to the object.

What is the magnitude of the acceleration of the object as it begins to move?

(The gravitational field strength g is $10\,\text{N kg}^{-1}$.)

A $5.0\,\text{m s}^{-2}$

B $7.25\,\text{m s}^{-2}$

C $7.5\,\text{m s}^{-2}$

D $8.0\,\text{m s}^{-2}$

E $10\,\text{m s}^{-2}$

F $10.5\,\text{m s}^{-2}$

ENGAA S1 2016 - Question 48 - Worked Solution

The magnitude of the applied horizontal forces is $\sqrt{9^2 + 12^2} = 15.0\text{N}$

The maximum frictional force $= \mu mg = 0.25 \times 2 \times 10 = 5\text{N}$

Therefore there is a resultant force of 10.0N 0n the object

$$\Sigma \quad f = ma$$

$$a = 5\text{ms}^{-1}$$

Answer is A

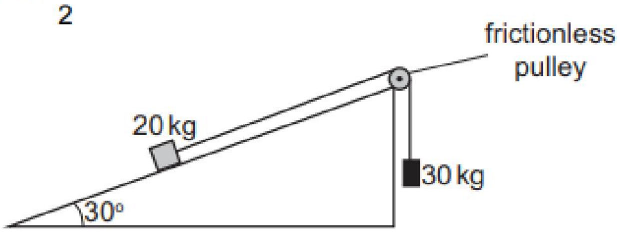
ENGAA S1 2016 - Question 50

50 An object of mass 20 kg is pulled up a rough plane inclined at 30° to the horizontal by a light, inextensible cable attached via a frictionless pulley to a freely-falling 30 kg mass. The acceleration of the object along the plane is 2.5 m s^{-2}.

$$\cos 30° = \sin 60° = \frac{\sqrt{3}}{2}$$

$$\sin 30° = \cos 60° = \frac{1}{2}$$

[diagram not to scale]



What is the frictional force between the object and the plane?

(Air resistance and the mass of the pulley can be ignored. The gravitational field strength g is 10 N kg^{-1}.)

A 25 N

B 50 N

C 75 N

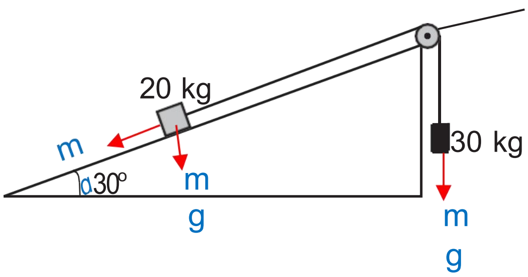
D 100 N

E 150 N

F 175 N

G 250 N

ENGAA S1 2016 - Question 50 - Worked Solution



$$\Sigma \quad F = ma$$

Following mass :

$$mg - T = ma$$

$$30 \times 10 - T = 30 \times 2.5$$

$$T = 225N$$

Mass on slope :

$$T - F_R - mg \sin \sin \theta = ma$$

$$225 - F_R - 20 \times 10 \times \frac{1}{2} = 20 \times 2.5$$

$$225 - 100 - 50 = F_R$$

$$F_R = 75N$$

Answer is C

ENGAA S1 2016 - Question 52

52 A spacecraft of initial total mass 4000 kg is travelling relative to the Earth at a constant speed of 7425 m s^{-1}.

It ejects some fuel backwards in a sudden burst at a speed relative to the spacecraft of 1425 m s^{-1}. As a result of this, the speed of the spacecraft immediately after the fuel is ejected increases to 7500 m s^{-1}.

What is the mass of fuel ejected?

A 22 kg

B 34 kg

C 40 kg

D 50 kg

E 200 kg

F 210 kg

ENGAA S1 2016 - Question 52 - Worked Solution

Beware : the mass of fuel has a speed of 1425ms^{-1} relative to the rocket, which itself moving forward at 7425ms^{-1} when the fuel is ejected.

As a result , the fuel has a velocity of 6000ms^{-1} in the same direction as the rocket relative to an observer outside the rocket.

$$(4000)(7425) = (\Delta M)(6000) + (4000 - \Delta M)(7500) \text{ BY Conservation of P}$$

$$2.97 \times 10^7 = 6000\Delta M + 4000 \times 7500 - 7500\Delta M$$

$$2.97 \times 10^7 = 3 \times 10^7 - 1500\Delta M$$

$$-3 \times 10^{-5} = -7500\Delta M$$

$$\Delta M = 200 \text{ kg}$$

Answer is E

Alternatively consider the problem in the rockets frame of the references , in which the rocket is initially at rest.

$$v_1 = 7500 - 7425 = 75ms^{-1}$$

$$v_2 = 1425ms^{-1}$$

$$\Delta M v_2 = (M - \Delta M)v_1$$

$$1425\Delta M = 75(4000 - \Delta M)$$

$$1500\Delta M = 3 \times 10^5$$

$$\Delta M = 200 \text{ kg}$$

Note : This is called the center of mass frame