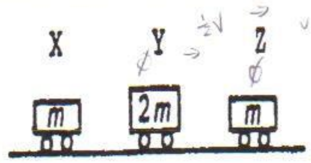
Name: Uni Lee

Grade 12 University Physics Celebration #3 2

K/U	C	A
[redacted] /16	[redacted] 9 /10	[redacted] /24

Part A: KNOWLEDGE

1. Three cars are on a straight frictionless track. Cars X and Z each have mass m, Y has mass $2m$. Initially, Y and Z are at rest and X moves toward them with speed v. Car X collides elastically with Y, which then collides elastically with Z.



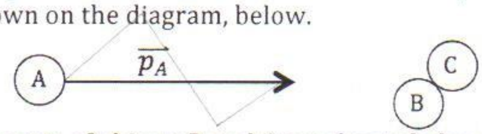
Answer: E ✓

After the collisions, which one of the following statements is true?
(a) X and Y are at rest; Z moves to the right with speed v.
(b) X is at rest; Y and Z move to the right.
(c) Y is at rest; X and Z each move away from Y.
(d) X and Y move to the left; Z moves to the right.
(e) X moves to the left; Y and Z move to the right.

2. An earth satellite is in a stable circular orbit. A booster rocket puts it in another circular orbit of somewhat larger radius. Which one of the following statements is <u>false</u>?
(a) The period of the satellite is increased.
(b) The gravitational attraction experienced by the satellite is decreased.
(c) The kinetic energy of the satellite is decreased
(d) The gravitational potential energy of the satellite is increased.
(e) The orbital speed of the satellite is increased.

Answer: ~~C~~

3. Object A is moving to the right, when it collides with two stationary objects. The momentum of object A, before the collision is shown on the diagram, below.



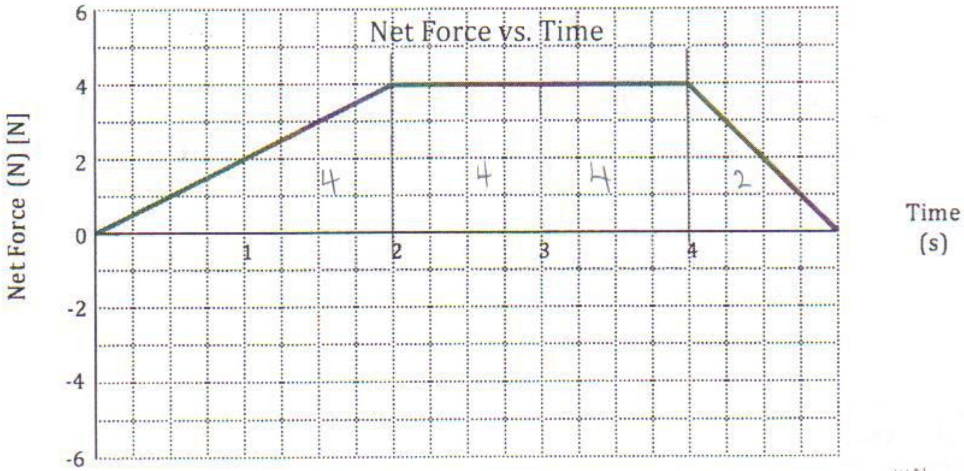
After the collision, the momenta of objects B and C are shown below.

Which of the following best represents the momentum of A, after the collision?

A B C D E

Answer: D ✓

4. A 2.0 kg object is moving at a velocity of 3.0 m/s [S], across a frictionless surface. During the next 5.0 s, a force acts on the object, as shown in the following graph:



a) While this force is applied, what is the impulse given to the object? $\frac{14N}{5s} = 2.8 \times 10^0 \frac{N}{s}$

b) What is the velocity of the object, afterwards? F=ma 14 = 2 a=7 3.8×10^1 m/s

5. The diameter of a black hole is 1.24×10^5 m. What is the mass of the black hole?

6. A 4.0 kg object is travelling at 12.0 m/s [N], prior to a head-on elastic collision with a 6.0 kg object that is travelling at 6.0 m/s [S]. After the collision, what is the velocity of:

a) the ~~12.0~~ 4.0 kg object? 3.6×10^0 m/s [S]

b) the 6.0 kg object? 1.4×10^1 m/s [N]

7. An object (object A) collides elastically with a stationary object (object B). Prior to the collision, object A had a velocity of $\overrightarrow{v_A}$. In terms of $\overrightarrow{v_A}$, what is the minimum possible velocity of object B, after the collision?

$\vec{V}_B' = \left(\frac{2m_A}{m_A+m_B}\right)V_A$ 0

8. A 3.4 kg object is attached to the end of a spring that has a force constant of 95 N/m. The other end of the spring is attached to the ceiling. The system is allowed to go to equilibrium. The 3.4 kg object is then pulled down 25.0 cm and released.

a) What is the acceleration of the object, when it is:

i) 15.0 cm above equilibrium? 4.2×10^0 m/s^2 dir?

ii) 10.0 cm below equilibrium? 2.8×10^0 m/s^2 dir? $\frac{1}{2}$

b) What is the period of the object's motion? 1.2×10^0 s

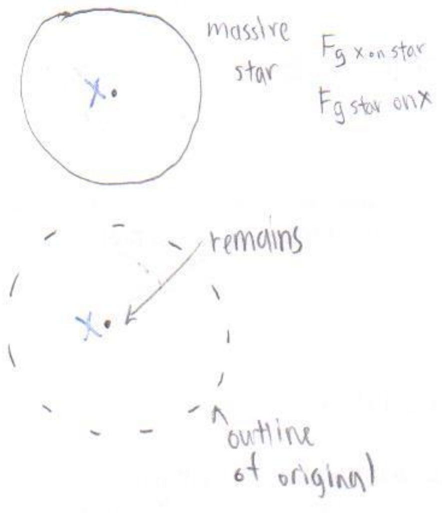
9. A cannon that is sitting on a frictionless surface, has a mass of 1250 kg. The cannon fires a cannonball that has a mass of 10.0 kg, at a velocity of 290.0 m/s [W]. What is the velocity of the cannon after the cannonball leaves it?

2.32×10^0 m/s [E]

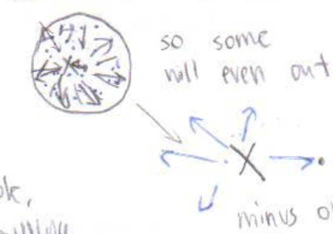
3.5

2. A black hole is the remains of a massive star. At a point very close the centre of the original star (and also very close to the centre of the black hole), is the gravitational field strength of the black hole larger, smaller or equal to that of the original star? Explain your answer.

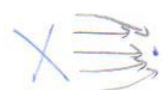
[3]



grav field strength is stronger than original because gravitation strength is the force of one object to another when its big, each particle pulls on the object at X,



when its a black hole, all of the particles pulling in one direction

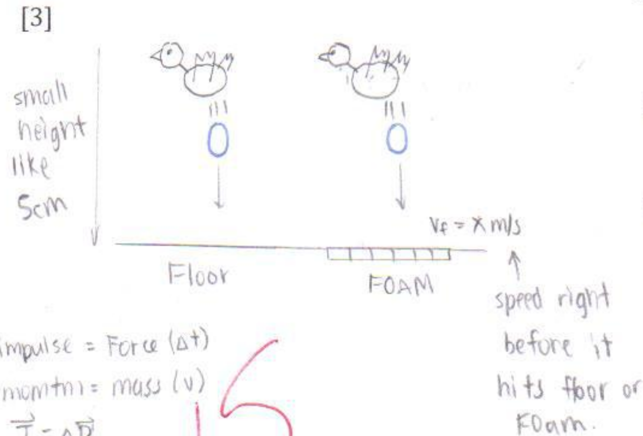


2.5

could be explained a little more clearly

3. An egg is dropped from a small height. Explain using impulse and momentum, how the egg will break when it hits the floor, whereas the egg will not break when it lands on a small piece of foam.

[3]



impulse = Force (Δt)
momtm = mass (v)
$\vec{J} = \Delta \vec{p}$
$= p_f - p_i$
$= mv_f - mv_i$

1.5

Egg will break when it hits the floor because impulse is Force × Time. (Ns). Force will be the same for both because gravity and height and mass is the same, but time in contact is different.

Floor contact time is like 0.1 s and egg stops. Whereas the foam slows it down because it will squish down making egg contact time longer like 1s when impulse is lower, means difference in $mv_f - mv_i$ is not a lot so it didnt slow down a lot so it'll crack :(

impulses are identical

10. In another solar system, a planet that revolves around the star takes 275 earth days to complete one revolution. The orbital radius of the planet is 1.63×10^{11} m.

a) What is the Kepler's 3[rd] law constant of proportionality for the star? $7.67 \times 10^{15} \ \frac{m^3}{s^2}$ ✓

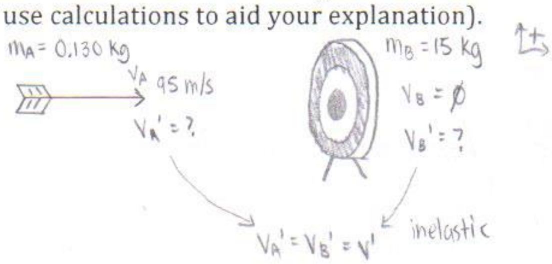
b) Another planet takes 423 earth days to orbit around the star. What is the planet's orbital radius? 2.17×10^{11} m ✓

11. In yet another solar system, two planets are orbiting around the central star. Planet A's orbital period is T_A. Planet B's orbital radius is 16 times planet A's orbital radius. Express planet B's orbital period, in terms of planet A's orbital period. $T_B = \cancel{4\sqrt{T_A}}$

Part B: COMMUNICATION

1. A person shoots an arrow that has a mass of 130 g at a target that has a mass of 15.0 kg. Just prior to hitting the target, the arrow is travelling east at 95 m/s. The arrow hits the target and sticks into it. The target doesn't move. A grade 12 physics student analyzes the situation and states the momentum was not conserved during this interaction. Was the student correct? Explain your answer (you may use calculations to aid your explanation).

[4]



$\uparrow + \rightarrow$

momentums always conserved.

student incorrect

0.5

$$\vec{P}_A' + \vec{P}_B' = \vec{P}_A + \vec{P}_B$$

$$m_A \vec{v}' + m_B \vec{v}' = m_A \vec{v}_A + \cancel{m_B \vec{v}_B} \quad v_B = \emptyset$$

$$0.13\,kg\,\vec{v}' + 15\,kg\,\vec{v}' = 0.13\,kg\,(95\,m/s)$$

$$15.13\,kg\,\vec{v}' = 12.35\,\frac{kg\,m}{s}$$

$$\vec{v}' = 0.816259...\,m/s\,[\rightarrow]$$

this is not an insignificant $\vec{v}$

because $\vec{v}'$ is so litte compared to the arrow, it looks like it doesnt move. because the arrows so light, its momentum is low. The target is a lot heavier so it is harder to move, so to the G12 student's eyes, it seems momentum wasnt conserved. Friction on floor and target wont tip over from a little arrow.

(it is noticeable)

→ but if you look super closely, the arrow in the target moves [→] very very little.

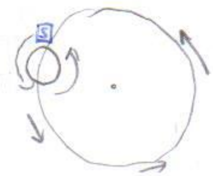
Part C: APPLICATION

1. Some astronauts on the surface of Mars, wish to put a satellite in geosynchronous orbit around Mars. The period of Mars' orbit is 686.97 Earth days, while the period of Mars' rotation is 24.62 hours The mass of the satellite and its propulsion system is 2850 kg. Assume that the mass of the satellite and its propulsion system doesn't change during the satellite's trip.

[8]

a) What is the orbital radius of ~~a satellite~~ this satellite?

24.62h
=88632s



686.97 days = 59354208 s

$T = \sqrt{\frac{4\pi^2 R^3}{GM}}$

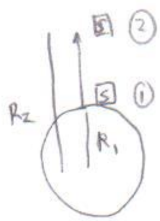
$= \sqrt{4\pi}$

$\boxed{S}$ m = 2850 kg

$E_{k_2} \neq 0$:(

r-mars 3.40×10^6 m

b) How much energy is required to put this satellite in geosynchronous orbit?



$E_{M_1} = E_{M_2} + E_{added}$

$m_2 = M$ = mars mass 6.37×10^{23} Kg

$m_1 = m$ = satellite 2850 Kg

$\cancel{E_{k_1}} + E_{g_2} = \cancel{E_{k_2}} + E_{g_2} + E_{added}$

$\cancel{\frac{1}{2}mv^2} + -\frac{Gm_1m_2}{R_1} = \cancel{\frac{1}{2}m_1v^2} + \left(-\frac{Gm_1m_2}{R_2}\right) + E_{add}$

$-\frac{6.67 \times 10^{-11} \frac{Nm^2}{kg^2}(m_1 m_2)}{3.40 \times 10^6 m} = -\frac{6.67 \times 10^{-11} \frac{Nm^2}{kg^2}(6.37 \times 10^{23} kg)(2850 kg)}{R_2} + E_{add}$

2

2. A vertical spring has a length of 1.00 m. One end of the spring is attached to the ground, the other end is free. A 3.00 kg mass is placed on top of the spring. The force constant of the spring is 294.3 N/m. The system is allowed to go down to equilibrium.

[7]

How much does the spring compress, as it goes down to equilibrium? (final answer only)

$F_g = mg$ $\qquad \Sigma\vec{F} = -kx$

$= 29.43$ $\qquad -29.43 = -k(294.3)$

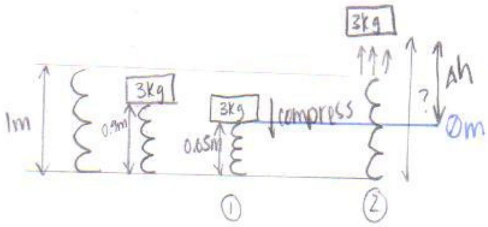
$k = -0.1$

compresses 0.1 m

The mass is then used to compress the spring another 25.0 cm. The mass is then released. What is the maximum height, above the ground, that the mass will reach?

$E_s\ E_g\ E_E\ E_K$

$K = 294.3\ \frac{N}{m}$



$x_1 = ?$

$-\frac{1}{2}$

givens?

$E_{K1} = E_{K2}$

not Δh!

$E_{s1} + E_{g1} + E_{K1} = E_{s2} + E_{g2} + E_{K2}$

$V_1 = \emptyset$ $\qquad V_2 = \emptyset$

$\frac{1}{2}kx_1^2 + \cancel{mg\Delta h_1} + \cancel{\frac{1}{2}mv_1^2} = \cancel{\frac{1}{2}kx_2^2} + mg\Delta h_2 + \cancel{\frac{1}{2}mv_2^2}$

$\frac{1}{2}(294.3\ \frac{N}{m})(0.25m)^2 = (3kg)(9.81\ m/s^2)(\Delta h_2)$

$9.196875\ J = 29.43\ \frac{kg\,m}{s^2}(\Delta h_2)$

$\Delta h_2 = 0.3125\ m$

∴ rises above unstretched length, cannot measure x_1 from equilibrium! XX

height above ground $= \Delta h_2 + 0.65\ m$

$= 0.3125m + 0.65m$

$= 0.9625m$

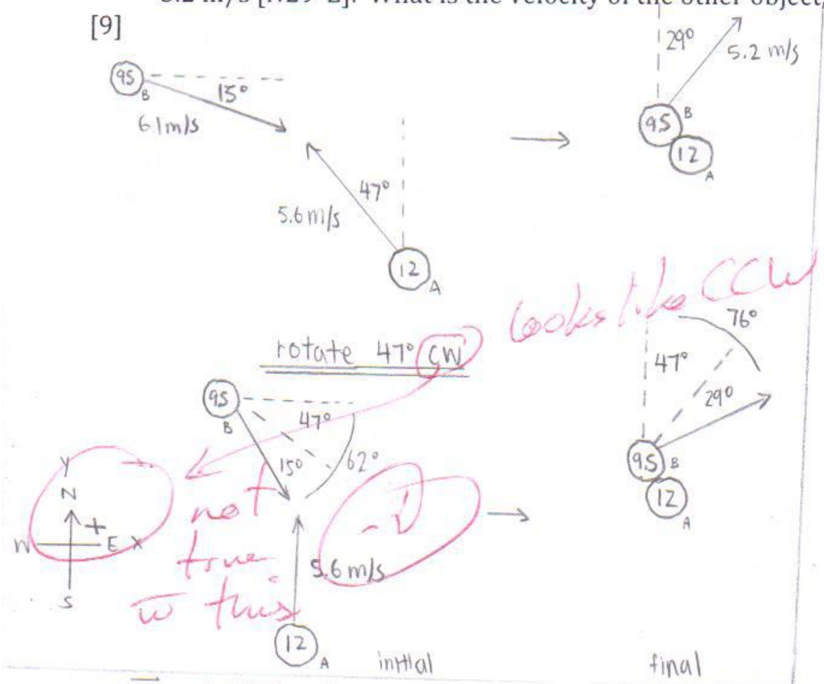
$\doteq 0.962\ m$

∴ It'll reach a height of 9.63×10^{-1} m above the ground

4.5

3. Two objects are involved in a glancing collision. Prior to the collision, one of the objects (which has a mass of 12.0 kg) is travelling at 5.6 m/s [N47°W], while the other object (which has a mass of 9.5 kg) is travelling at 6.1 m/s [E15°S]. After the collision, the 9.5 kg object has a velocity of 5.2 m/s [N29°E]. What is the velocity of the other object, after the collision?

[9]



some issues w/ detailing

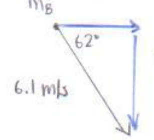
-4

$|\vec{V_A}'| = \sqrt{(0.322706... m/s)^2 + (1.72723... m/s)^2}$

$= 1.757117707... m/s$

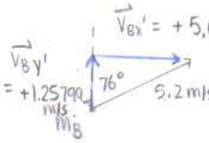
$\doteq 1.8$ m/s

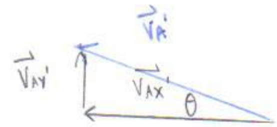
$\vec{V_{Bx}} = +2.86377... m/s$



$\vec{V_{By}} = -5.474275... m/s$

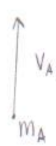
$\vec{V_{Bx}}' = +5.0455377... m/s$



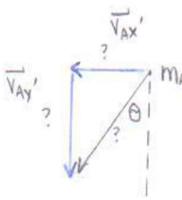


$\tan\theta = \frac{V_{Ay}'}{V_{Bx}'}$

$= \frac{0.322706... m/s}{1.72723... m/s}$



$V_{Ay} = +5.6$ m/s



$m_B = 9.5$ kg

$m_A = 12$ kg

$\theta = 10.5828...°$

$\doteq 11°$

rotate 47 CCW

= 36°

X dir

$\vec{P_{Ax}}' + \vec{P_{Bx}}' = \cancel{\vec{P_{Ax}}} + \vec{P_{Bx}}$ ← switch X = Y

$(9.5 kg)(2.86377... m/s) = (12 kg)(\vec{V_{Ax}}') + (9.5 kg)(+5.0455377... m/s)$

$27.205815... \frac{kg\,m}{s} = 12 kg\,\vec{V_{Ax}}' + 47.93260815... \frac{kg\,m}{s}$

$-\frac{20.726793... \frac{kg\,m}{s}}{12 kg} = \vec{V_{Ax}}'$

$\vec{V_{Ax}}' = -1.727232763... m/s$

Y dir

$\vec{P_{Ay}} + \vec{P_{By}} = \vec{P_{Ay}}' + \vec{P_{By}}'$

$m_A \vec{V_{Ay}} + m_B \vec{V_{By}} = m_A \vec{V_{Ay}}' + m_B \vec{V_{By}}'$

$(12 kg)(+5.6 m/s) + (9.5 kg)(-5.474275... m/s) = (12 kg)(\vec{V_{Ay}}') + (9 kg)(+1.25799... m/s)$

$15.19438... \frac{kg\,m}{s} = 12 kg(\vec{V_{Ay}}') + 11.32191 \frac{kg\,m}{s}$

$3.8724775 \frac{kg\,m}{s} = 12 kg(\vec{V_{Ay}}')$

$\vec{V_{Ay}}' = 0.322706... m/s$

$\boxed{\therefore \text{ the velocity of the 12 kg is } 1.8 \text{ m/s [W36°S]}}$

How much kinetic energy was "lost" as a result of this collision?

lost 2.2 × 10² J

-1

E_{K1}

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

$= \frac{1}{2}(9)(6.1)^2 + \frac{1}{2}(12)(5.6)^2$

$= 355.605$ J

E_{K2}

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

$= \frac{1}{2}(9)(5.2)^2 + \frac{1}{2}(12)(1.757)^2$

$= 140$ J

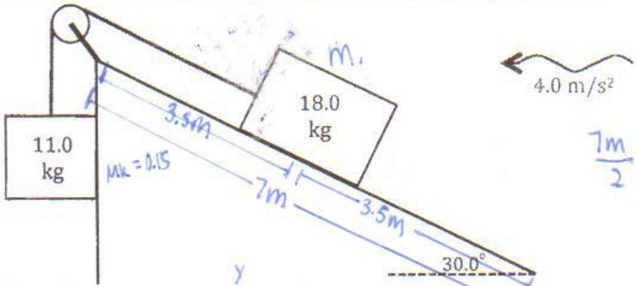
7/15

Uni Lee

Grade 12 U Physics – TIPS 2

10.5/16

An 11.0 kg mass is attached to an 18.0 kg mass, by an ideal rope. The 18.0 kg mass is on an incline plane (which is inclined at an angle of 30.0°). The 11.0 kg mass is suspended over the edge of the incline plane (see the accompanying diagram). The 11.0 kg mass is just touching the vertical surface of the incline plane. The coefficient of kinetic friction between any two surfaces that are in contact is 0.15. The incline plane has a length of 7.0 m, and the 18.0 kg mass is in the middle of it. A force (applied to the incline plane) causes the inclined plane to undergo uniform acceleration of 4.00 m/s² [left]. (See the accompanying diagram)
How long will it take the 18.0 kg mass to reach the end of the incline plane?
Hint: In a non-inertial frame of reference, fictitious forces can appear to be active!



$\frac{7m}{2} = 3.5m$

Why does friction act in the chosen dir?

Given for this? (-2)

$\Delta d = \cancel{v_1(\Delta t)} + \frac{1}{2} a (\Delta t)^2$

$+3.5m = \frac{1}{2}(0.08395... m/s^2)(\Delta t)^2$

rearrangement

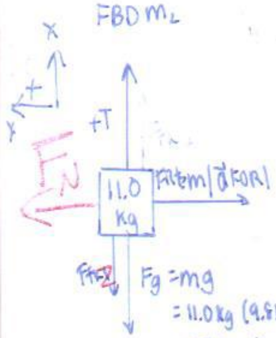
$\Delta t = 9.13\ s$

rounded from?

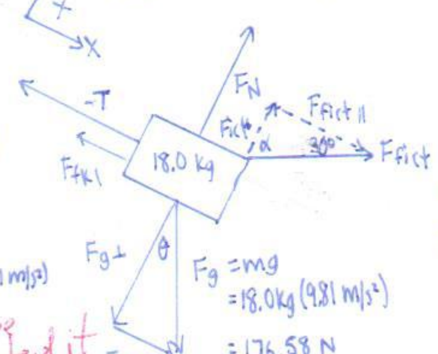
∴ it takes 9.1×10^0 s to reach the end.

2-SD

FBD m_2



FBD m_1



$\Sigma \vec{F}_{y2} = m\vec{a}$ ⓪

$0 = -F_{g\perp} + F_N + F_{fict\perp}$

$F_N = +F_g - F_{fict\perp}$

$F_{fict} = m|\vec{a}_{FOR}|$
$= 18.0 kg (4.0 m/s^2)$
$= 72\ N$

$F_g = mg$
$= 11.0 kg (9.81 m/s^2)$
$= 107.91\ N$

$\vec{F}_{ict} = m|\vec{a}_{FOR}|$
$= 11.0 kg (4.0 m/s^2)$
$= -44\ N$

you've treated it as a vector

$F_g = mg$
$= 18.0 kg (9.81 m/s^2)$
$= 176.58\ N$

$\vec{F}_{fk1} = F_N (\mu_k)$
$= (F_g - F_{fict\perp})(0.15)$
$= 140.58\ N (0.15)$
$= 21.087\ N$

FN

$F_{fk2} = F_g (\mu_k)$
$= (11.0 kg)(9.81 m/s^2)(0.15)$
$= 16.1865\ N$

$F_{g\parallel} = F_g (\sin\theta)$
$= 176.58\ N (\sin 30°)$
$= 88.29\ N$

$F_{g\perp} = F_g (\cos\theta)$
$= 176.58 N (\cos 30°)$
$= 152.9227...\ N$

$\vec{ma} = \Sigma F_{x1}$

$18 kg(\vec{a_y}) = (-T) + (-F_{fk1}) + (F_{fict\parallel}) + (F_{g\parallel})$

$18 kg(\vec{a_y}) = (-T) + (-21.087N) + (62.3538N) + (88.29N)$

$T = 129.5568\ N - 18 kg(\vec{a_y})$ ②

FN ?

$F_{fk2} = T (0.15)$
$= 0.15\ T$

$\alpha = 180° - 90° - 30°$
$= 60°$

sub ① into ②

$\frac{107.915 + 11 kg\, \vec{a}}{0.85} = 129.5568N - 18 kg\, \vec{a}_y$

$107.915N + 11kg\, \vec{a}_y = 0.85(129.5568 N - 18 kg\, \vec{a}_y)$

$107.915N + 11kg\, \vec{a}_y = 110.123...N - 15.3 kg\, \vec{a}_y$

$26.3 \vec{a}_y = 2.208\ N$

$\vec{a}_y = 0.08395...\ m/s^2$

$ma = \Sigma F_{x2}$

$11.0 kg(\vec{a_x}) = (+T) + (-F_{fk1}) + (-F_g)$

$11.0 kg(\vec{a_x}) = (+T) + (-0.15T) + (-107.91N)$

$= 0.85T + (-107.915) - 11 kg\, \vec{a}_y$

$T = \frac{+107.915 + 11 kg(\vec{a_y})}{0.85}$ ①

$F_{fict\parallel} = F_{fict}(\sin\alpha)$
$= 72N(\sin 60°)$
$= 62.3538...\ N$

$F_{fict\perp} = F_{fict}(\cos\alpha)$
$= 72N(\cos 60°)$
$= 36N$