Physics Revision Exercises

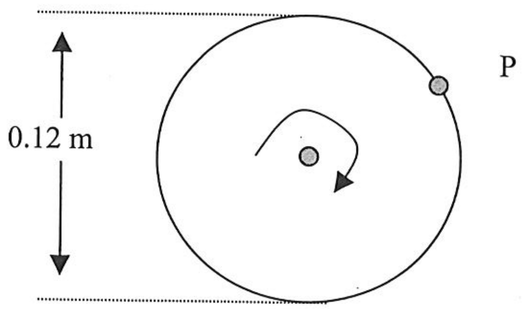
Suggested Solutions to the following topics:

1. Circular Motion
2. Gravitational Field
3. Kinematics
4. Newton's Laws
5. Physics of Fluids
6. Linear Momentum
7. Forces
8. Work, Energy and Power

Compiled by the Physics Year 1 2003 Team

Additional Exercises – Circular Motion

1. A grinding wheel of diameter 0.12 m spins horizontally about a vertical axis, as shown in the diagram below. P is a typical grinding particle bonded to the edge of the wheel.



a. If the rate of rotation is 1200 revolutions per minute, calculate

(i) the angular velocity, [126 rads^{-1}]

$$f = 1200 \text{ rev per min} = \frac{1200}{60} \text{ rev per secs}$$

$$\omega = 2\pi f = 126 \text{ rads}^{-1}$$

(ii) the acceleration of P, [947 ms^{-2}]

$$a = r\omega^2 = 0.06 \times 126^2 = 947 \text{ ms}^{-2} \approx 950 \text{ ms}^{-2}$$

(iii) the magnitude of the force acting on P if its mass is 1.0 x 10^{-4} kg. [9.47 x 10^{-2} N]

$$F = ma = 1.0 \times 10^{-4} \times 947 = 9.47 \times 10^{-2} \text{ N}$$

b. The maximum radial force at which P remains bonded to the wheel is 2.5N. Calculate the angular velocity at which P will leave the wheel if its rate of rotation is increased. [645 rads^{-1}]

By Newton's 2nd Law:

$$2.5 = mr\omega^2 = 1.0 \times 10^{-4} \times 0.06 \times \omega^2$$

$$\omega = 645 \text{ rads}^{-1}$$

2. At one instant, the rotational speed of a disc in a CD player is 300 revolutions per minute.

a. Calculate the angular velocity of the disc. [31.4 rads^{-1}]

$$\omega = 2\pi f = 2 \times \pi \times \frac{300}{60} = 31.4\ rads^{-1}$$

b. Sketch a graph to show how the acceleration, *a*, of a point on the disc varies with its radial distance, *r*, from the axis of rotation when the disc is moving with constant angular velocity.

Since ω is a constant, and $a = r\omega^2$, therefore a graph of a against r gives a straight line passing through the origin and gradient = ω^2.

c. P and Q are two points on the disc, 30 mm and 50 mm respectively from the axis of rotation.

(i) Calculate the difference in the linear speeds of the two points. [0.628 ms^{-1}]

From $v = r\omega$,

$$v_P = 30 \times 10^{-3} \times 31.4$$

$$v_Q = 50 \times 10^{-3} \times 31.4$$

$$v_Q - v_P = (50 - 30) \times 10^{-3} \times 31.4 = 0.628\ ms^{-1}$$

(ii) What is the difference in the angular velocities of the two points?

Since it is given that ω is a constant, the two points should have the same angular velocity.

3. A record is played at 45 revolutions per minute, and then at 33 $^{1}/_{3}$ revolutions per minute. Find the ratio of the centripetal accelerations of a point on the rim of the record. [1.82]

At f_1 = 45 revolutions per minute, $a_1 = r\omega^2 = r\,(2\pi f_1)^2$

At f_2 = 33.3 revolutions per minute, $a_2 = r\omega^2 = r(2\pi f_2)^2$

$$\frac{a_1}{a_2} = \left(\frac{f_1}{f_2}\right)^2 = \left(\frac{45}{33.3}\right)^2 = 1.82$$

4. The reading of a speedometer fitted to the front wheel of a bicycle is directly proportional to the angular velocity of the wheel. A certain speedometer is correctly calibrated for use with a wheel of diameter 66 cm but, by mistake, is fitted to a 60 cm wheel. Explain whether the indicated linear speed would be greater or less than the actual speed and find the percentage error in the readings. [10%]

Let R represent the readings on the speedometer.

$R \quad = r\omega$

Since it is calibrated for $r = 33$ *cm, at an angular velocity of* ω, *the speedometer will give a reading of* $R_0 = 0.33\omega$

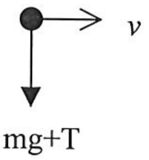
Since the actual radius of the wheel is 30 cm, the actual speed of the bicycle is given by $v = 0.30\omega$

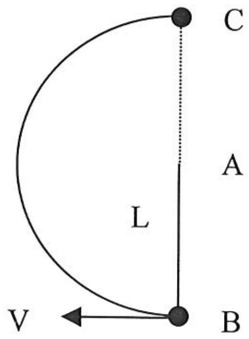
Comparing R_0 *and v, the speedometer will indicate a linear speed that is higher than the actual speed of the bicycle.*

The % error in the reading $= \dfrac{0.33\omega - 0.30\omega}{0.30\omega} \times 100\% \quad = \quad$ *10%*

5. Refer to Q32 (TYS).

(a) At C, applying Newton's 2^{nd} *Law:*





$$mg + T = \frac{mv^2}{L} > mg \text{ (for string to be taut)}$$

$$v^2 > gL$$

$$v > \sqrt{gL} \text{ (shown)}$$

(b) By principle of conservation of energy,

Total mechanical energy at B $=$ *Total mechanical energy at C*

$$\frac{1}{2}mV^2 + mgh_B = \frac{1}{2}mv^2 + mgh_c$$

$$\frac{1}{2}mV^2 = \frac{1}{2}mv^2 + mgh_c - mgh_B$$

$$V^2 = v^2 + 2g\,(h_c - h_B)$$
$$= gL + 2g(2L)$$
$$= 5gL$$

$$V = \sqrt{5gL}$$

MCQ (TYS) – page 79

Q6. There are only two forces acting on the aircraft, the weight and the lift.

Q17. Given that f is a constant, therefore ω should also be a constant. Since $v = r\omega$, graph of v against r should give a straight line passing through the origin.

Q19. Since v is a constant. From $v = r\omega$ or $\omega = \frac{v}{r}$, therefore, ω should be proportional to $\frac{1}{r}$.

Q20. There is no displacement along the vertical plane therefore there is no component of resultant along the vertical plane. In the horizontal plane, there is centripetal acceleration, hence according to Newton's 2nd law, there must be a resultant force in the direction of the centripetal acceleration.

Q21. Uniform circular motion ⇒ linear speed and angular velocity is constant. Both linear velocity and linear acceleration are not constant because their direction is changing.

Q22. Constant linear speed ⇒ there is no force along the tangential direction to change the speed, therefore tangential acceleration = 0. Centripetal acceleration = $\frac{v^2}{r}$.

Q23. Linear speed, $v = \frac{Distance}{time} = \frac{2\pi r}{1.0}$. Centripetal acceleration = $\frac{v^2}{r}$.

Q24. Constant speed ⇒ kinetic energy is a constant. Momentum has direction & is therefore not constant.

Q25. Use $v = r\omega$ and note that ω is the same for both cases.

Q26. $T + mg = \frac{mv^2}{r}$

Q27. $\frac{mv^2}{r} = \frac{GMm}{r^2}$, therefore $v^2 \propto \frac{1}{r}$.

Gravitational Field Additional Questions 2003

A space capsule is travelling between the Earth and the Moon. Using the data below, find the distance from the Earth at which it is subjected to zero resultant force. (Consider only the gravitational fields of the Earth and the Moon.)

Mass of the Earth = 6.0×10^{24} kg

Mass of the Moon = 7.4×10^{22} kg

Distance between the centres of the Earth and the Moon = 3.8×10^{8} m

[3.4×10^{8} m]

Solution:

When space capsule experiences zero resultant force,
gravitational force on capsule by Earth = that on capsule by Moon

$$\Rightarrow \frac{GM_E m}{x^2} = \frac{GM_M m}{(a-x)^2},$$

where M_E = mass of Earth; M_M = mass of Moon; m = mass of space capsule; x = distance from Earth; a = distance between the centres of the Earth and the Moon

$$\Rightarrow \frac{6.0\times10^{24}}{x^2} = \frac{7.4\times10^{22}}{(3.8\times10^8 - x)^2}$$

$$\Rightarrow (7.4\times10^{22})x^2 = (6.0\times10^{24})((3.8\times10^8)^2 - 2(3.8\times10^8)x + x^2)$$

$$\Rightarrow (5.926\times10^{24})x^2 - (4.56\times10^{33})x + 8.664\times10^{41} = 0$$

$\Rightarrow$ $\underline{x = 3.4 \times 10^{8}\text{ m}}$.

(a) (i) State Newton's law of gravitation. Give the meaning of any symbol you use.

(ii) Define *gravitational field strength.*

(iii) Use your answers to **(i)** and **(ii)** to show that the magnitude of the gravitational field strength at the Earth's surface is GM / R^2, where M is the mass of the Earth, R is the radius of the Earth and G is the gravitational constant.

(b) A communications satellite occupies an orbit such that its period of revolution about the Earth is 24 h. Show that the radius, R_o, of this orbit is given by

$$R_o = 574\sqrt[3]{GM},$$

where G and M have the same meanings as in **(a)(iii)**.

Solution:

(a)(i) Newton's law of gravitation states that the magnitude of the force of attraction acting between two point masses m_1 and m_2 whose centres of mass are separated by a distance r is given by $F = \frac{Gm_1m_2}{r^2}$, where G is the universal gravitational constant.

(ii) The gravitational field strength at a point is defined as the gravitational force acting on a unit mass placed at that point.

(iii) Consider a unit mass placed at a point on the Earth's surface.

Gravitational field strength at Earth's surface
= gravitational force acting on the unit mass placed at Earth's surface (by **(ii)**)
$= \dfrac{GMm}{R^2}$, where $m = 1$ unit of mass (by **(i)**)
$= \dfrac{GM}{R^2}$ (shown)

(b) Gravitational force on satellite by Earth
= centripetal force which keeps satellite in circular motion about Earth

$$\Rightarrow \frac{GMm}{R_o^2} = mR_o\omega^2$$

$$\Rightarrow R_o^3 = \frac{GM}{(2\pi/T)^2}$$

$$\Rightarrow R_o = \sqrt[3]{\frac{GMT^2}{4\pi^2}} = \sqrt[3]{\frac{GM(24\times 60\times 60)^2}{4\pi^2}} = 574\sqrt[3]{GM}$$

Escape velocity

Given that the Earth's radius is 6.4×10^6 m and the acceleration due to free fall is $9.8\ \text{ms}^{-2}$, determine the velocity with which a rocket must be fired from the Earth's surface so as to escape the influence of the Earth's gravitational field. (Hint: To escape completely from the Earth's gravitational field, the rocket has to be infinitely far from the Earth in theory.) [$1.1 \times 10^4\ \text{ms}^{-1}$]

Solution:

By the principle of conservation of energy,
Loss in kinetic energy of rocket = Gain in its gravitational potential energy from Earth's surface to infinity

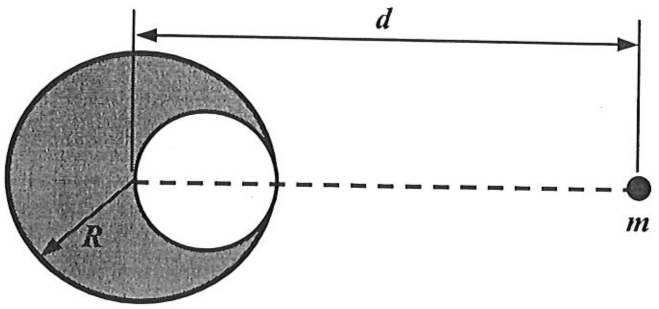
$$\Rightarrow \frac{1}{2}mv^2 - 0 = 0 - \left(-\frac{GMm}{R}\right),$$

where m and M are the masses of the rocket and the Earth respectively, R is the radius of the Earth and v is the escape velocity of the rocket.

$$\Rightarrow v = \sqrt{\frac{2GM}{R}}$$

But $g = \dfrac{GM}{R^2}$, so $v = \sqrt{2gR} = \sqrt{2\times 9.8\times 6.4\times 10^6}$ = $\underline{1.1 \times 10^4\ \text{ms}^{-1}}$.

A spherical hollow is made in a lead sphere of radius R, such that its surface touches the outside surface of the lead sphere on one side and passes through its centre on the opposite side as shown in the diagram below. With what force, according to Newton's Law of universal gravitation, will the lead sphere attract a small sphere of mass m, which lies at a distance d from the centre of the lead sphere on the straight line connecting the centres of the spheres and of the hollow?



Solution:

Let the force the lead sphere with spherical hollow will attract the small sphere be F.
The entire original lead sphere (before the hollow is made) would exert a force

$$F' = \frac{GMm}{d^2}$$

on the small sphere.

The sphere removed, of radius $R/2$, would exert a force

$$F'' = \frac{G(M/8)m}{(d - R/2)^2}.$$

Since $F + F'' = F'$, and after some algebra, we obtain

$$F = \frac{GMm}{d^2}\left[1 - \frac{1}{8}\left(1 - \frac{R}{2d}\right)^{-2}\right].$$

KINEMATICS ADD EX

1. $v^2 = u^2 + 2as$

$0 = u^2 + 2(-5.0)(40)$

$u = 20\ ms^{-1}$ (initial vel)

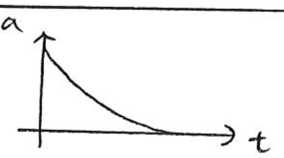
$v = u + at$ ($\uparrow$ is +ve)

$v = 20 + (-5)(6.0)$

$= -10\ ms^{-1}$

$\boxed{\text{Ans : B}}$

2. $\boxed{\text{Ans : C}}$



3. $V_x = 10 \cos 60$

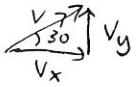
$= 5\ ms^{-1}$

which is constant

if $\theta = 30°$

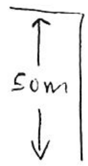
$V = \dfrac{V_x}{\cos 30} = \dfrac{5}{\cos 30}$

$= 5.8\ ms^{-1}$



$\boxed{\text{Ans : A}}$

4. a) $s = ut + \frac{1}{2}at^2$ ($\downarrow$ +ve)



$50 = (-20)t + \frac{1}{2}gt^2$

$4.9t^2 - 20t - 50 = 0$

$t = \dfrac{20 \pm \sqrt{20^2 - 4(4.9)(-50)}}{2(4.9)}$

$= 5.83s$ or $\cancel{-1.7s}$

b) Time of flight of 2nd stone

$= 4.83s$

$s = ut + \frac{1}{2}at^2$ ($\downarrow$ is +ve)

$50 = u(4.83) + \frac{1}{2}(9.8)(4.83)^2$

$u = -13.3\ ms^{-1}$

c) $v^2 = u^2 + 2as$ (1st stone)

$= 20^2 + 2(9.8)(50)$

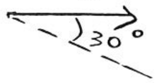
$v = 37.1\ ms^{-1}$

$v^2 = u^2 + 2as$ (2nd stone)

$= 13.3^2 + 2(9.8)(50)$

$v = 34.0\ ms^{-1}$

5 a.) $V_x = 200\ ms^{-1}$



V_x (with respect to ground)

$= 200 + 500 \cos 30°$

$= 633\ ms^{-1}$

$s_y = ut + \frac{1}{2}at^2$

$= (500 \sin 30°)(10) + \frac{1}{2}(9.8)(10)^2$

$= 2990m$

b)

$s_x = u_x t$

$= (633)(10)$

$= 6330m$

c) $V_y = u_y + at$

$= (500 \sin 30) + (9.8)(10)$

$= 348\ ms^{-1}$

$V_x = 633\ ms^{-1}$ (const., same as initial)

New

1. A force of 5.0 N is applied to

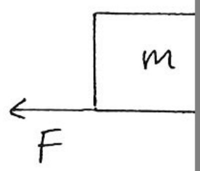
$F = ma \Rightarrow$

2. In a catapult, a stone of mas
distance of 30 cm. What avera

$v^2 = u^2 + 2as \Rightarrow$

$F = ma$

3. A box of mass 5.0 kg is pull
angle of 20° to the horizontal.
(a) Draw a labelled free-body
(b) Calculate the acceleration



In the above problems:

1. What is the key equation here?

   In what situation(s) would you

   What is the physical principle a

2. What are the key equation(s) he

   Why do you think the force is "

   Is there another approach to sol

   conservation of energy

3. What questions do you ask whe

   How do you decide which force

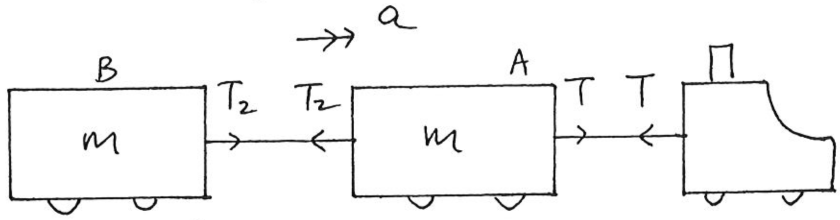
   Can you apply concepts of net f

   Yes : Horizontally → net force

   What technique do you apply to

   Vector components (

4. A railway engine pulls two carriages of equal mass with uniform acceleration. The tension in the coupling between the engine and the first carriage is T. Deduce the tension in the coupling between the first and second carriages.



$F_{net} = ma$

Consider

A & B : $T = (2m)a$ ①

B alone : $T_2 = ma = \frac{1}{2}T$ ② //

Things to ponder...

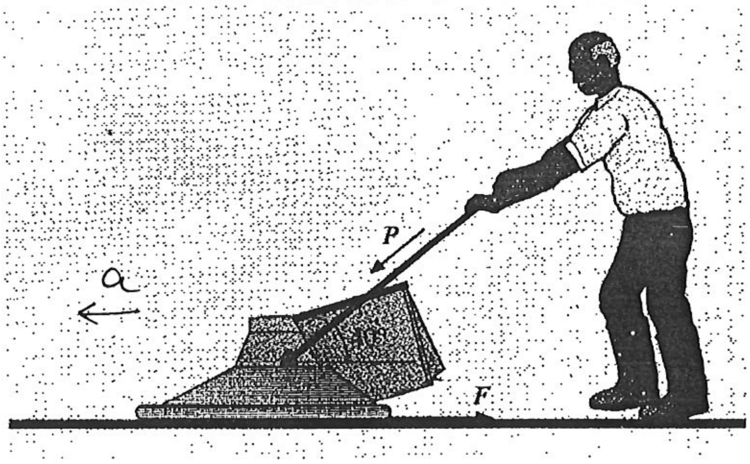
4. Is there another free-body diagram that you can use?
If yes, work out the answer again.

Yes, Consider A alone : $T - T_2 = ma$

from above ① $2ma - T_2 = ma$

$T_2 = ma = \frac{1}{2}T.$ //

5. A gardener pushes a lawnmower of mass 18 kg at constant speed. To do this requires a force ***P*** of 80 N directed along the handle, which is at an angle of 40° to the horizontal (see diagram below).
(a) Calculate the horizontal retarding force ***F*** on the mower.
(b) If this retarding force were constant, what force applied along the handle, would accelerate the mower from rest to 1.2 m s^{-1} in 2.0 s? [61 N, 94 N]



a) Constant speed
$\Rightarrow F_{net} = 0$

$P \cos 40° = F$

$F = 80 \cos 40° = 61.28$
$\simeq 61$ N.

b) F : constant
P : changes.

$F_{net} = ma$: $P\cos\theta - F = ma$ ①

$P = \frac{ma + F}{\cos\theta}$ (more sf.)

$= \frac{18(0.6) + 61.28}{\cos 40°}$

$= 94.09 \simeq 94$ N //.

$v = u + at$ ②

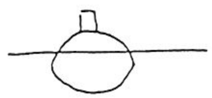
$a = \frac{v-u}{t}$

$= \frac{1.2 - 0}{2.0}$

$= 0.6$ ms^{-2}

ajl@njc

1. $\rho_w = 1030\ kg\,m^{-3}$



$V_s = 250\ m^3$

$M_s = 25\times10^3\ kg$

By Principle of floatation,
weight of seawater displaced = Wt. of submarine

$$m_w g = m_s g \quad \text{———} \ (1)$$

Volume of seawater displaced, $V_w = \dfrac{M_w}{\rho_w}$

$$= \frac{m_s}{\rho_w}$$

$$= \frac{25\times10^3}{1030}$$

$$= 24.3\ m^3$$

Proportion of submarine under the water

$$= \frac{V_w}{V_s}\times100$$

$$= \frac{24.3}{250}\times100$$

$$= \underline{9.72\ \%}$$

OR

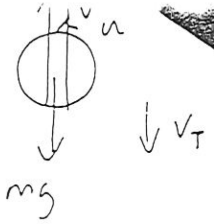
From (1), $V_w \rho_w = V_s \rho_s$

$$\frac{V_w}{V_s} = \frac{\rho_s}{\rho_w} = \frac{25000 \div 250}{1030}$$

2. $V = 3.0\times10^{-5}\ m^3$

(i) $\rho = 7800\ kg\,m^{-3}$

$\eta = 1.5\ kg\,m^{-1}s^{-1}$



Ignoring upthrust, u :

$$mg - F_v = 0$$

$$F_v = mg \qquad (F_v = 6\pi r \eta V_T)$$

$$6\pi r\eta V_T = mg \quad -\ (1)$$

Volume of sphere, $V = \frac{4}{3}\pi r^3 = 3.0\times10^{-5}\ m^3$

$$3.0\times10^{-5} = \frac{4}{3}\pi r^3$$

$$r = 0.0193\ m$$

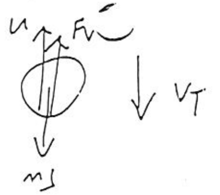
$\therefore$ in eq^2 (1): $V_T = \dfrac{mg}{6\pi r\eta}$

$$= \frac{(\rho V)g}{6\pi r\eta}$$

$$= \frac{(7800)(3.0\times10^{-5})(9.81)}{6\pi(0.0193)(1.5)}$$

$$= \underline{4.21\ ms^{-1}}$$

(1) $\rho_{gly} = 1260\ kg\,m^{-3}$,



u = wt. of fluid displaced (Archimedes' Principle)

$= m_{gly} \cdot g$

$= \rho_{gly} \cdot V_{gly} \cdot g$

$V_{gly} = V_{ball}$

$\therefore u = \rho_{gly} \cdot V_{ball} \cdot g$

$= 1260 \cdot 3.0 \times 10^{-5} \times 9.81$

$= \underline{0.371\ N}$

When upthrust is not neglected,

$mg = F_v + u$

$mg = 6\pi r \eta v_T + \rho_{gly} \cdot V_{gly} \cdot g$

$$v_T = \frac{mg - \rho_{gly} \cdot V_{ball} \cdot g}{6\pi r \eta}$$

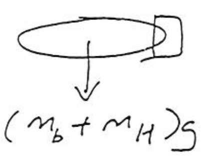
$$= \frac{g(\rho_{steel} \cdot V_{ball} - \rho_{gly} \cdot V_{ball})}{6\pi r \eta} \quad [\because m = \rho V]$$

$$= \frac{g(\rho_{steel} - \rho_{gly})\frac{4}{3}\pi r^{3}}{6\pi r \eta}$$

$$= \frac{2(\rho_{steel} - \rho_{glycerine})g r^2}{9\eta} \quad \text{(shown)}$$

3(a) $m_b = 4300\ kg$ | $\rho_H = 0.177\ kg\,m^{-3}$

$V_b = 5750\ m^3$



(i)

Total weight of blimp,

$W_T = W_B + W_H$

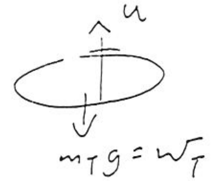
$= (m_b + m_H)g$

$= (4300 + \rho_H V_H)g$

$= [4300 + (0.177)(5750)]\,9.81 \quad \{V_b = V_H\}$

$= \underline{52.2\ kN}$

(ii) $m_T = m_b + m_H$



$u \geq W_T$

u = wt. of air displaced $= W_a$

$W_a \geq W_T$ for upward motion.

Additional load, W_A

$\therefore$ at equilibrium : $W_a = W_A + W_T$

$W_A = W_a - W_T$

$= \rho_a V_b \cdot g - 52.2 \times 10^3 \quad (\rho_a = 1.29\ kg\,m^{-3})$

$W_A = (1.29)(5790)(9.81) - 52.2 \times 10^3$

$= \underline{20.6 \text{ kN}}$

b) Pumping air into the ballonets increases the effective weight of the blimp. Since upthrust remains constant (as the blimp is rigid, it displaces a constant volume), blimp will descend.

c) $F_D = 26.9 \rho v^2$

$= 26.9(1.29)(1.20)^2$

$= 50.0 \text{ N}$

const speed

$F_{net} = 0$.

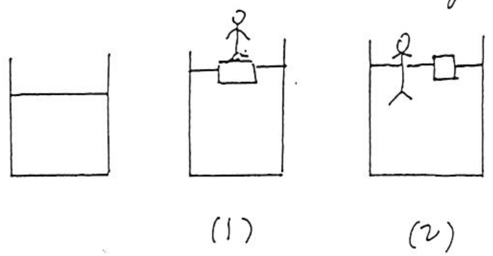
$\therefore F = F_D$

Power, $P = Fv$

$= (50.0)(1.20)$

$= \underline{60.0 \text{W}}$

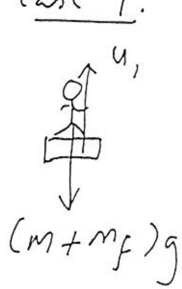
4. Consider a man and a rectangular float in the following cases:



ρ: density of water

m_L: mass of water displaced

Case 1: Increase in volume $= V_1$



Using Law of floatation:

Upthrust, U_1 = Wt. of water displaced, W_1

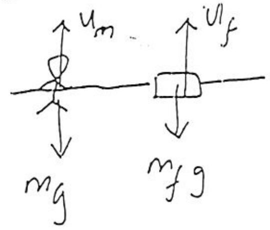
$W_1 = (m+m_f)g$

$m_L g = (m+m_f)g$

$\rho V_1 = (m+m_f)$

$V_1 = (m+m_f)/\rho$

Case 2: Increase in volume $= V_2$



Upthrust on man, U_m = Wt of water displaced by man, W_m

$W_m = mg$

$\rho V_m g = mg$

Volume displaced by man, $V_m = \frac{m}{\rho}$

Similarly, volume displaced by float, $V_f = \frac{m_f}{\rho}$

$\therefore V_2 = V_m + V_f$

$= \frac{m+m_f}{\rho} = V_1$

$\therefore$ there is no change in water level. Both Jack & Rose are wrong.

13

Pg 3

Q4. Qualitative Way of Explaining.

Situation 1 : The vol. of water displaced
is such that its weight balanced
that of boat and all the guests.

Situation 2 : Since the guests float on water,
the wt of water displaced still equals
that of guests and the boat.

Conclusion :
the water level
in each case is the
same.

Tutor can make use of this chance to
modify the scenario such that a steel ball
is on the boat, instead of the guests.
should the ball is thrown into the pool, the water level
in the pool is larger ~~than~~ before the ball is thrown

5. (i) $A_y = 5.0 \times 10^{-4}\ m^2$

$A_z = 30.0 \times 10^{-4}\ m^2$

$V_z = 2.0\ ms^{-1}$

Velocity at Y, $V_y = ?$

Using continuity equation:

$$A_y V_y = A_z V_z$$

$$V_y = \frac{A_z}{A_y} \cdot V_z$$

$$= \frac{30.0 \times 10^{-4}}{5.0 \times 10^{-4}} \times 2.0$$

$$= \underline{12.0\ ms^{-1}}$$

(ii) Pressure difference $P_y - P_z = ?$

Using Bernoulli's eq^2:

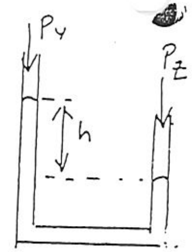
$$P_y + \frac{1}{2}\rho V_y^2 = P_z + \frac{1}{2}\rho V_z^2$$

$$P_y - P_z = \frac{1}{2}\rho (V_z^2 - V_y^2)$$

$$= \frac{1}{2}(1000)(2.0^2 - 12.0^2)$$

$$= \underline{-70\ kPa}$$

(iii)



$\rho_0 = 13.6 \times 10^3\ kgm^{-3}$

$$P_y + \rho_0 g h = P_z$$

$$P_y - P_z = -\rho_0 g h$$

$$-70 \times 10^3 = -13.6 \times 10^3 \times 9.81 \times h$$

$$h = \underline{0.525\ m}$$

6. The pressure difference between the inner and outer pane of the window

$$P = \frac{1}{2}\rho v_o^2 - \frac{1}{2}\rho v_i^2$$

$$= \frac{1}{2}(1.23)(30)^2 - 0$$

$$= 553.5\ Pa$$

The net force on window $= P \cdot$ Area

$= 553.5 (4.0 \times 5.0)$

$= 11.1\ kN.$ #

Linear Momentum

1. Both masses have the same change in momentum as the resultant force acting on them is the same, provided the time of application of the forces is the same, i.e A and B reach the finishing line together.

Ans: A

2. Change in momentum, Δp of

(i) $= -mv + 0 = -mv$

(ii) $= mv - 0 = mv$

(iii) $= 2mv$.

ans : (6)

3. Initially the ping-pong ball and the bowling ball have the same momentum. Hence the ping-pong is moving faster.

Since same force is exerted on them, they would experience the same Δp in the same time interval.

~~Thus their deceleration is the same.~~

$$F \cdot dt = \Delta p$$

The impulse is the same.

Conclusion: Both stop at the same time.

4. By conservation of momentum,

$$mu = 2mv$$

$$\underline{\underline{v = \frac{1}{2}u}}$$, absence of friction on airtrack.

5. For the rubber ball that bounces back, its $\Delta p \simeq 2mv$ if it does so with the same incident speed.

For the ball of putty, its $\Delta p \simeq \frac{1}{2}mv$.

$\therefore$ the rubber ball is more likely to topple the bowling pin since the Δp of the bowling pin will be larger (which is also $2mv$)

6. During collision, the force acting on each vehicle by the other is the same. (Newton's 3rd Law)
The impact time is the same.
Hence impulse, $F\Delta t$ is the same.
Thus both undergo the same Δp.
The car experiences a larger acceleration
since $F_{net} = ma$.
i.e m is inversely proportional to a.

7.

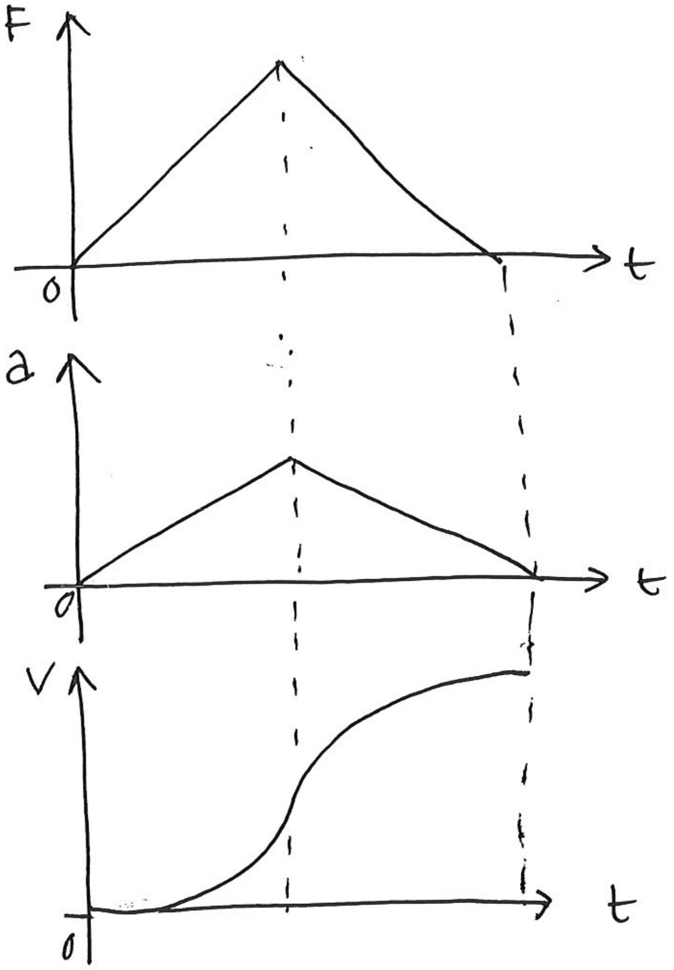
Considering car and Earth as a closed system,
the earth gains the same amt of momentum as the car.
Since $KE = \frac{p^2}{2m}$, the earth would have gained a smaller KE than car $\because$ its mass is much larger.

8a. Δp in 1st 1.0s $= \frac{4 \times 1}{2} = 2.0$ Ns

$P_i = 0$

$\therefore$ p at $t = 1.0$s is 2.0 Ns.

speed of body $= \frac{2.0}{1.0} = 2.0 \text{ ms}^{-1}$.



b. Speed of man just b4 landing, u

$= \sqrt{2(9.81)(0.50)}$

$= 3.13 \text{ ms}^{-1}$

Final momentum of man, $P_f = 0$.

$\Delta p = P_i = 80(3.13) = 250.57$ Ns

$\Delta p = F_{ave} \cdot \Delta t$

$\therefore F_{ave} = \frac{250.57}{0.013} = 19.3$ kN.

8c (i) $f_A = 0.13(1100)9.81 = 1402.83\ N$

$f_B = 0.13(1400)9.81 = 1785.42\ N$

Let u_A and u_B be the speed of the cars ~~at~~ immediately after impact.

$$V_A^2 = u_A^2 + 2a\,S_A$$

$$0 = u_A^2 - 2\left(\frac{f_A}{1100}\right)8.2$$

$$\therefore u_A = 4.57\ ms^{-1}$$

$$V_B^2 = u_B^2 + 2a\,S_A$$

$$0 = u_B^2 - 2\left(\frac{f_B}{1400}\right)(6.1)$$

$$u_B = 3.94\ ms^{-1}$$

(ii)

$$P_{A_i} + P_{B_i} = P_{A_f} + P_{B_f}$$

$$0 + P_{B_i} = 1100(4.57) + 1400(3.94)$$

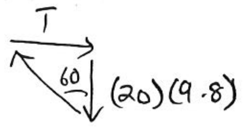
$$P_{B_i} = 10543$$

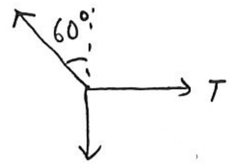
$$\therefore V_{B_i} = 10543 \div 1400$$

$$= 7.53\ ms^{-1}$$

FORCES ADD EX

1.





$T = (20)(9.8)\tan 60°$

$= 339\text{ N}$

$\boxed{\text{Ans : D}}$

2. $mg = kv$ ($\because$ const spd)

$v = \dfrac{mg}{k}$

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

$= \frac{1}{2}\dfrac{m^3g^2}{k^2}$

$\boxed{\text{Ans : C}}$

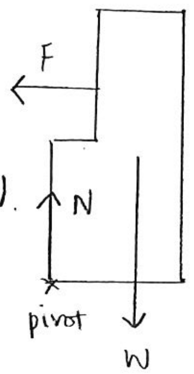
3. $(15)(\frac{2}{3}\cancel{a}) = T(2\cancel{a})$

$T = 5\text{ N}$

$\boxed{\text{Ans : D}}$

Hope this is right...

4. When h = 95 cm, it is the boundary pt. when ACW moment due to F just exceeds CW moment due to W. Thus,



$F(95) = W(30)$

$= (2500)(30)$

$F = 789\text{ N}$

5 a) Position A :

$(F_B)(40) = (10)(460) + (20)(150)$

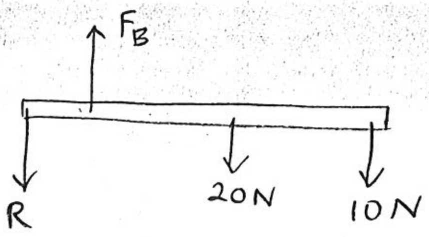
$F_B = 190\text{ N}$

Position B :

$(F_B\cos 45°)(40) = (10)(460) + (20)(150)$

$F_B = 269\text{ N}$

b) 1.

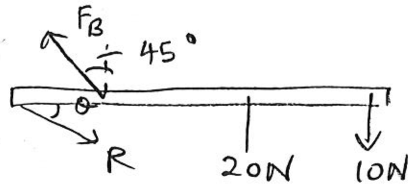


2. $F_B = R + 20 + 10$

$190 = R + 20 + 10$

$R = 160\text{ N}$

c)



$\Sigma F_y = 0$

$R\sin\theta + 20 + 10 = 190$

$R\sin\theta = 160$

$\Sigma F_x = 0$

$R\cos\theta = F_B\sin 45°$

$= 190$

$\tan\theta = \dfrac{160}{190}$

$\theta = 40.1°$

$R = 248\text{ N}$

WEP Additional Exercise Solutions

1) Work supplied to move box = Energy gained

Let W_T be the total work done by the force applied to push the box up the slope.

$$\frac{76}{100}(W_T) = mgh$$
$$= (200)(2)$$
$$= 400$$
$$W_T = \frac{400(100)}{76}$$
$$= 526\ J$$

$$W_T = F \times x$$
$$= 35x$$
$$35x = 526$$
$$x = 15m$$

Answer : D

2) Change in PE = Gain in KE

$$mg(h-d) = \frac{1}{2}mv^2$$
$$2g(h-d) = v^2$$
$$v = \sqrt{2g(h-d)}$$

Answer : C

4) Since F is constant,

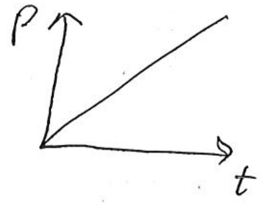
by $F = ma$, a is also constant.

Since a is constant, v is increasing at a constant rate.

And $P = Fv$,

F is constant, v is increasing at a constant rate,

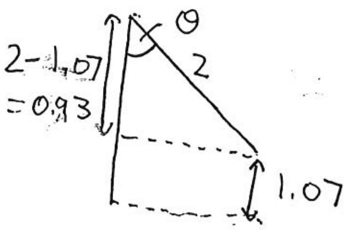
$\therefore$ P is increasing at a constant rate.

$\therefore$ Graph of P vs t would be 

5) Change in KE = Gain in PE

$$\frac{1}{2}(65)(5)^2 - \frac{1}{2}(65)(2)^2 = 65(9.81)(\Delta h)$$

$$\Delta h = 1.07\,m$$



$$\cos\theta = \frac{0.93}{2}$$

$$\theta = 62°$$

Ans: C

6a) Change in PE = Change in KE.

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

$$mg(10) = \frac{1}{2}mv_S^2$$

$$20g = v_S^2$$

$$v_S = \sqrt{20g}$$

$$= 14\ ms^{-1}$$

$$mg(10) - mg(8) = \frac{1}{2}mv_T^2$$

$$mg(2) = \frac{1}{2}mv_T^2$$

$$4g = v_T^2$$

$$v_T = \sqrt{4g}$$

$$= 6.26\ ms^{-1}$$

b) Total energy at Q $= \frac{1}{2}mv_Q^2 + mg(6)$

= Total energy at R

$= mg(10)$

$$\frac{1}{2}mv_Q^2 + mg(6) = mg(10)$$

$$\frac{1}{2}v_Q^2 + 6g = 10g$$

$$v_Q = \sqrt{8g} = 8.9\ ms^{-1}$$

c) Potential energy + kinetic energy (At Q)

$\Rightarrow$ Potential energy (At R)

$\Rightarrow$ Kinetic energy (At S)

7) a) A constant force F is applied to a body moving at speed V_x to bring it to rest.

$$a = \frac{F}{m}$$

$$V_i^2 = u^2 + 2as$$

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

$$2Fs = mV_x^2$$

$$Fs = \frac{1}{2}mV_x^2$$

= net work done on body by F

= Initial KE of body.

b) (i) Increase in PE = mgh

$= 1200(9.81)\left(\frac{1}{5} \times 1600\right)$

$= 3.8 \times 10^6$ J

(ii) Increase in KE = $\frac{1}{2}mv^2$

$= \frac{1}{2}(1200)(20)^2$

$= 2.4 \times 10^5$ J

7b (iii) Work done $= 210(1600)$

$= 3.4 \times 10^5$ J

(iv) Total work done $= 3.4 \times 10^5 + 3.8 \times 10^6 + 2.4 \times 10^5$

$= 4.34 \times 10^6$ J

Average Power $= \dfrac{4.34 \times 10^6}{3 \times 60}$

$= 24$ kW