Hwa Chong Institution Examinations
Secondary 3 Integrated Programme

CANDIDATE NAME

CLASS

REGISTER NUMBER

PHYSICS **October 2020**

Paper 1 and 2 Answers

-1 mark for any number of sf/dp mistakes
-1 mark for any number of unit mistakes (for the final answer)
-1 mark for any number of presentation mistakes (no written formulas)

Paper 1

1	**A**	11	**B**	21	**A**
2	**C**	12	**A**	22	**B**
3	**C**	13	**D**	23	**D**
4	**C**	14	**D**	24	**C**
5	**D**	15	**C**	25	**A**
6	**B**	16	**A**	26	**B**
7	**B**	17	**B**	27	**C**
8	**B**	18	**A**	28	**A**
9	**A**	19	**C**	29	**B**
10	**A**	20	**B**	30	**D**

Paper 2

SECTION A (40 MARKS)

*Answer **all** the questions in this section.*

1 Fig. 1.1 and 1.2 show the readings on a vernier caliper with the jaws closed and with a test tube clamped between its jaws respectively.

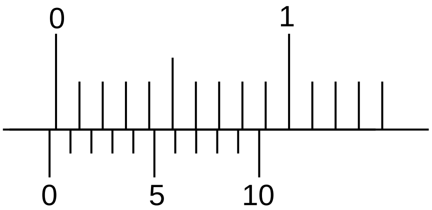


Fig. 1.1

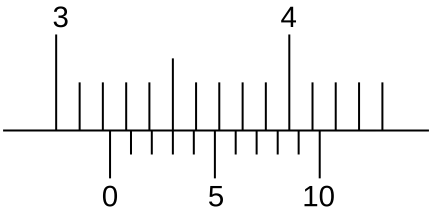


Fig. 1.2

(a) Write down the zero error of the vernier caliper.

-0.03 cm [1]

[1]

(b) Determine the actual diameter of the test tube.

Observed reading: 3.20 cm + 0.03 cm = 3.23 cm [1]
Actual reading: 3.23 cm – (-0.03 cm) = 3.26 cm [1]

[2]

(c) Besides zero error, name a systematic error that could occur when conducting this measurement.

Parallax error / poor grip of object / object is grip slanted / expansion of scale / vernier scale is calibrated wrongly. [any point is 1 mark]

[1]

2 Diamond is useful for industrial applications and jewellery. The cut of a diamond affects how light gets transmitted into the eye of the observer when light passes through diamond. The depth of its pavilion from its crown governs the path light will travel when it enters the diamond from the outside.

A diamond that has a good cut is one that allows most light rays to exit from the top of the crown when light is shone from any angle around it. An incident ray of light is allowed to enter the surface of the diamond as shown in Fig. 2. The refractive index of diamond is 2.4 and its critical angle is approximately 25 °.

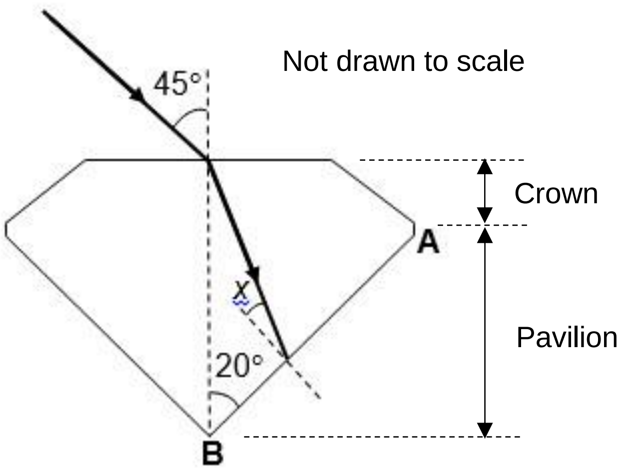


Fig. 2

(a) Calculate the speed of light in diamond given the speed of light in air is 3.0×10^8 m s^{-1}.

v = c / n
v = 3.0 x 10^8 / 2.4
= 1.3 x 10^8 m/s [1]

[1]

(b) Given the angle of incidence that light enters the diamond is 45 °, find the angle of incidence, *x*, that the light ray hits surface **AB**.

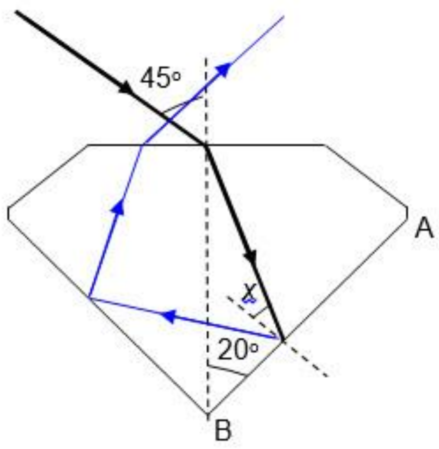
sin i / sin r = n ⇒ r = 17° [1]
***x* = 180° - 17° - 90° - 20°**
= 53° [1]

[2]

(c) Complete the path of the light ray in Fig. 2 to show how it exits the top of the diamond. (Note: the diagram is not drawn to scale) [2]

[1] – Total internal reflection at X and Y.
[1] – Refracted ray bends away from normal at Z.
Subtract 1 mark if any of the three arrows are not drawn.

Accept if light ray (after TIR) hits the crown but i = r.

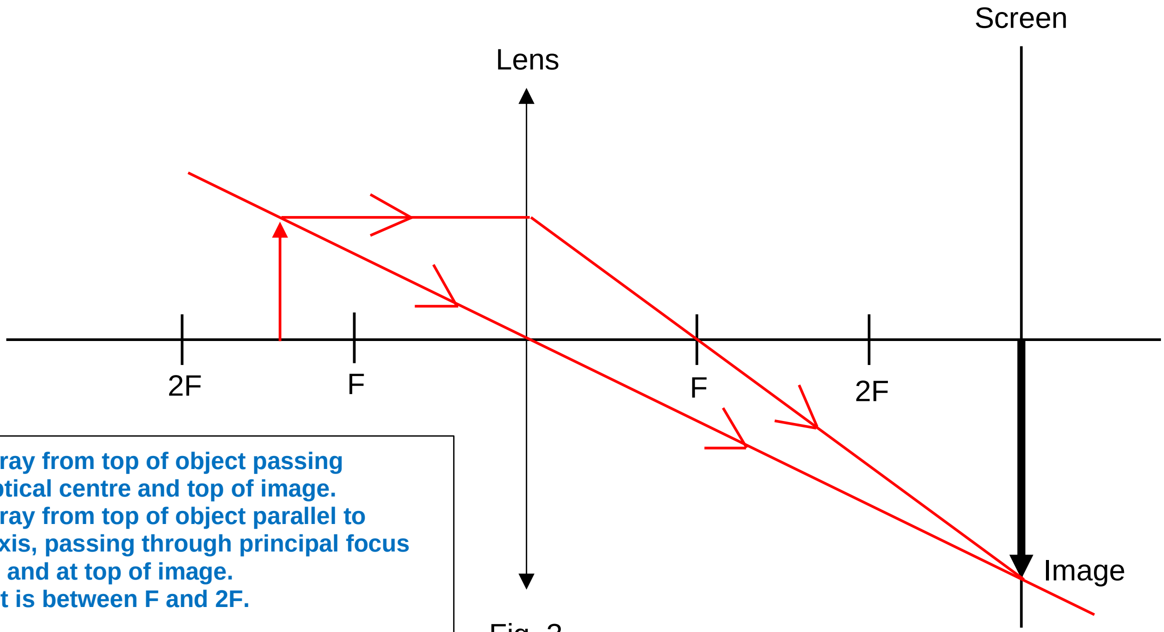


(d) The depth of the pavilion plays a pivotal role in how light gets reflected internally and thus how bright a diamond sparkles. With reference to Fig. 2, explain why a diamond with a shallower pavilion will not shine as brightly as one with a deeper pavilion.

A shallower pavilion means when light rays hit one of the faces of the pavilion, the angle of incidence on that face will be smaller than the critical angle [1]. Instead of being totally internally reflected and exiting from the crown, more lightrays will get refracted and exit the diamond from the top of the pavilion [1].
[2]

3 Fig. 3 shows a sharp image being formed on a screen placed in front of a thin converging lens.

(a) Complete Fig. 3 to show how the ray diagram can be used to determine the position of the object.



[1] – Light ray from top of object passing through optical centre and top of image.
[1] – Light ray from top of object parallel to principal axis, passing through principal focus (after lens) and at top of image.
[1] – Object is between F and 2F.

Subtract 1 mark if arrows are not drawn for each light ray (before and after the lens)

Fig. 3

[3]

(b) When a permanent marker is used to shade the upper half of the lens, the image on the screen looks different. Identify the difference and suggest a reason for the difference.

The image formed will be <u>less bright / dimmer [1]</u> as <u>half / some of the light energy is blocked / absorbed by the marker ink [1]</u>. [Blur not allowed [2]

4 Fig. 4 shows a 400 N weight supported by two strings, inclined at angles 30 ° and 50 ° to the vertical respectively. By drawing a scaled diagram, determine the tensions in both strings. State the scale used.

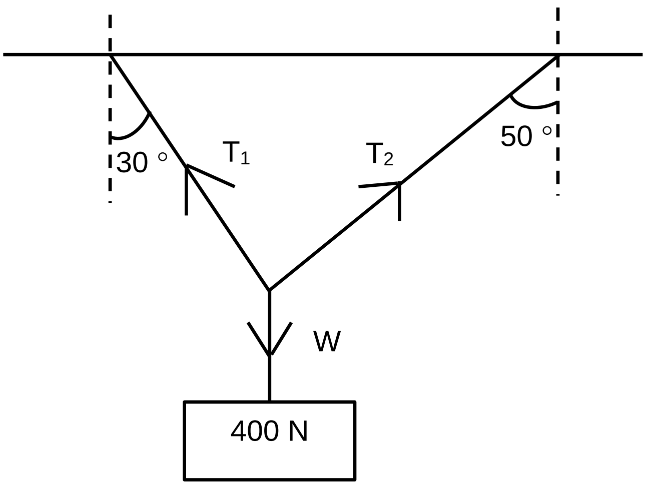
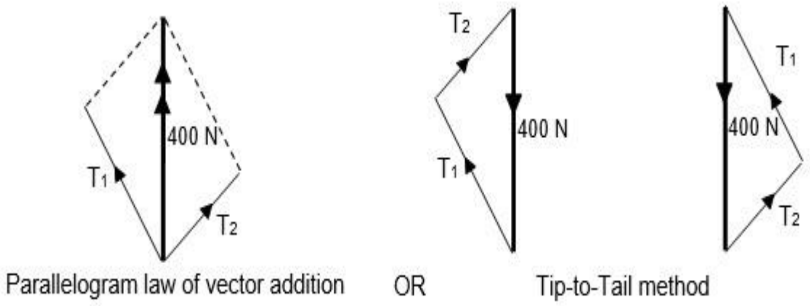


Fig. 4



- correct drawing of resultant force with correct arrows (400 N) [1]
- correct drawing of T_1 and T_2 with correct arrows [1]
- Appropriate scale used (at least 1.0 cm rep. 50 N) [1] No mark if use = sign.
- magnitude of T_1 = 310 N (accept 300 to 320 N) [1]
- magnitude of T_2 = 200 N (accept 190 to 210 N) [1]

[5]

5 Fig. 5.1 shows a ball placed at the top of a slope. A block is fixed rigidly to the lower end of the slope.

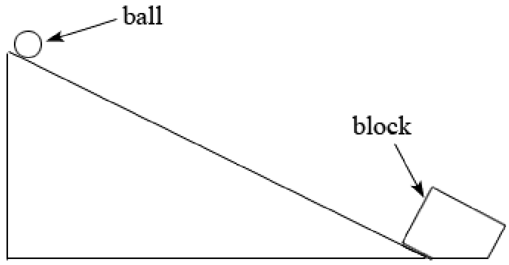


Fig. 5.1

The ball of mass 0.70 kg, initially at rest, is released from the top of the incline and the velocity of the ball rolling down the slope is found to vary with time as shown in the velocity-time graph as shown in Fig. 5.2.

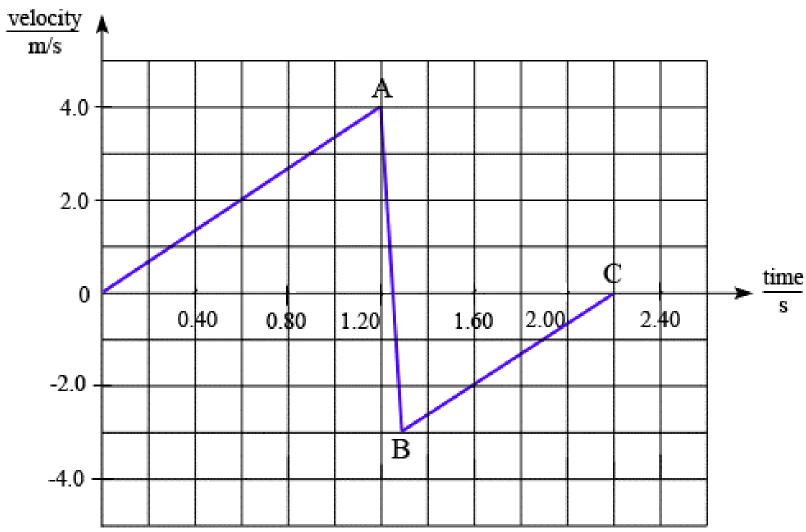


Fig. 5.2

(a) Describe the motion of the ball during the following periods:

(i) 0A

Starts from rest and moving down the slope with constant increasing velocity / constant acceleration [1]

(ii) AB

(Sharp) constant deceleration as the ball hits the block (from A to v = 0) [1] and thereafter, (sharp) constant acceleration from v = 0 to B [1].

or

Award [1] if student mentioned there is a change in direction.
0 mark if student wrote deceleration from A to B.

[2]

(b) Explain why the speed at B is less than the speed at A.

Some energy will be lost as heat and sound [1] as the ball hits the block.

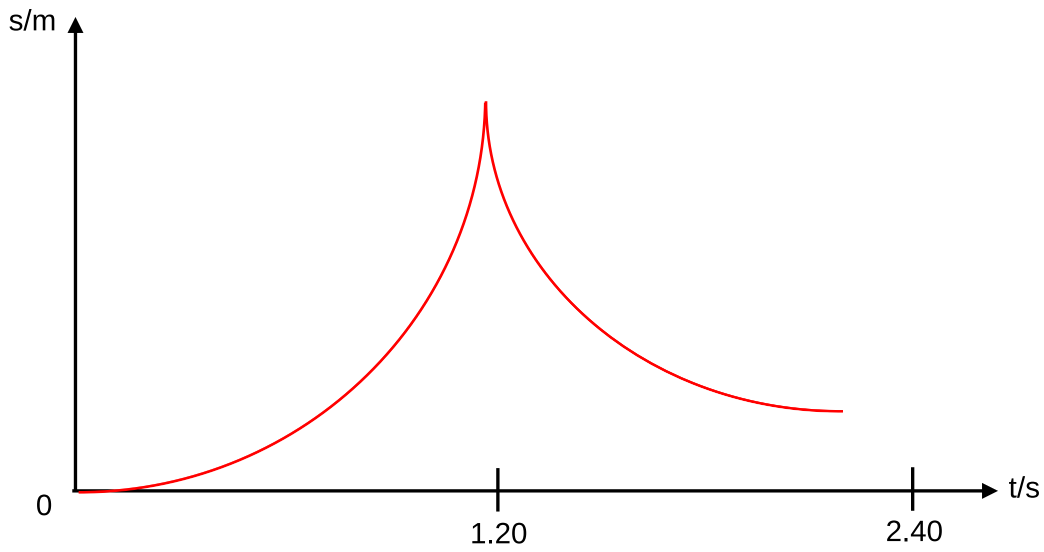
[1]

(c) Calculate the acceleration of the ball down the inclined slope.

Acceleration down the incline = (4.0 – 0) / 1.20 [1]
= 3.3 ms^{-2} [1]

[2]

(d) Sketch a displacement-time graph of the motion of the ball for t = 0 s to t = 2.20 s. The axes are drawn for you below.



[1] – Increasing positive gradient for t = 0 to 1.20 s.

[1] – Decreasing negative gradient for t = 1.20 to 2.20 s (approx).

[2]

6 Table 6 shows a table of data of planetary radius and masses.

Planet	**Radius / 10^6 m**	**Mass / 10^{25} kg**
Earth	6.38	0.597
Jupiter	71.5	190
Mars	3.40	0.0640
Mercury	2.44	0.0330
Neptune	24.8	10.2

Table 6

The gravitational field strength, *g*, depends on the mass of the planet (in kg) and the radius of the planet (in m), given by the relationship:

$$g = \frac{6.67\times10^{-11}\times \text{mass of planet}}{(\text{radius of planet})^2}$$

(a) Using the above relationship and the information in Table 6, calculate the weight of a 65.0 kg astronaut on earth.

$$\boldsymbol{g}\ \textbf{(Earth)} = \frac{6.67\times10^{-11}\times 0.597\times10^{25}}{(6.38\times10^{6})^2}$$

= 9.78 N/kg [1]

Weight = 65.0 × 9.78
= 636 N [1]

[2]

(b) The mass and weight of the astronaut is now measured on Neptune.

(i) Suggest how the measurements on Neptune would be different from those measured on Earth.

No change in mass as it depends on the amount of matter in the bodyand is independent with location. The weight on Neptune will be greater than Earth. [1 mark for both mass and weight] [1]

(ii) Explain, with numerical evidence, your answers in 6(b)(i).

$$\frac{6.67\times10^{-11}\times 10.2\times10^{25}}{(24.8\times10^{6})^2}$$

= 11.1 N/kg > *g* (Earth)

[1]

(c) A spacecraft travelled past Neptune and took several pictures. It is programmed to send signals of these pictures back to Earth and is detected by big-dish antenna on Earth as shown in Fig. 6.

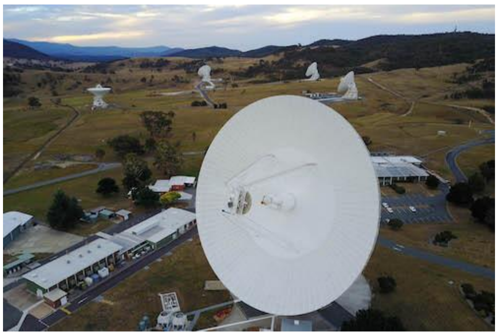


Fig. 6

(i) Identify the component in the electromagnetic spectrum that is used to send these signals.

Radio wave / Microwave [1]. [1]

(ii) Suggest a reason why this component is used.

Radio can travel through a vacuum / does not need a medium to travelfrom one point to another / Travel far distance / Long or large or big wavelength [1]

7 An experiment, as shown in Fig. 7, involves heating a thin-wall aluminium container that is half-filled with water. A small opening is made at the top of the container.

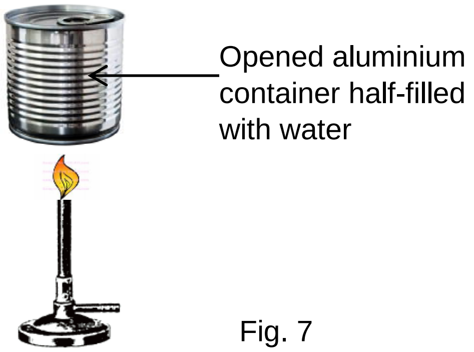


Fig. 7

(a) Using kinetic theory of matter, explain how air pressure is exerted on the walls in the container.

According to kinetic theory of matter, air molecules move in a random and continuous manner. As they move, they collide with the walls of the container [1] exert a force on the walls. The average force per unit area exerted by the molecules results in pressure [1]. [2]

(b) After some time, the Bunsen burner is turned off and the container is sealed. Ice water is poured over it.

Describe and explain what will happen to the sealed container when ice water is poured over it.

The sealed container is crushed / volume decreased [1]. As cold water is poured over the container, the temperature of the air and its average kinetic energy of the molecules inside the container decreases. As a result, the air pressure in the container decreases [1]. As the pressure of the air outside the container is greater than the air pressure inside the container / a net force is exerted on the outer walls of the container by the atmospheric pressure [1] and crushing it from the outside. [3]

SECTION B (30 Marks)

Answer question 8, 9 and either 10A or 10B in this section

8 The stopping distance travelled by a car depends on many factors. Two of the physical factors – road condition and the condition of the tyres – which determine whether the car stops or skids on braking is considered in this situation here. During wet road condition, a patterned tyre with (full tread) will allow water between the tyre and the road to be channelled out while a bald tyre does not.

Fig. 8.1 shows how the maximum possible friction between a car tyre and the road varies with the speed of the car under wet road conditions.

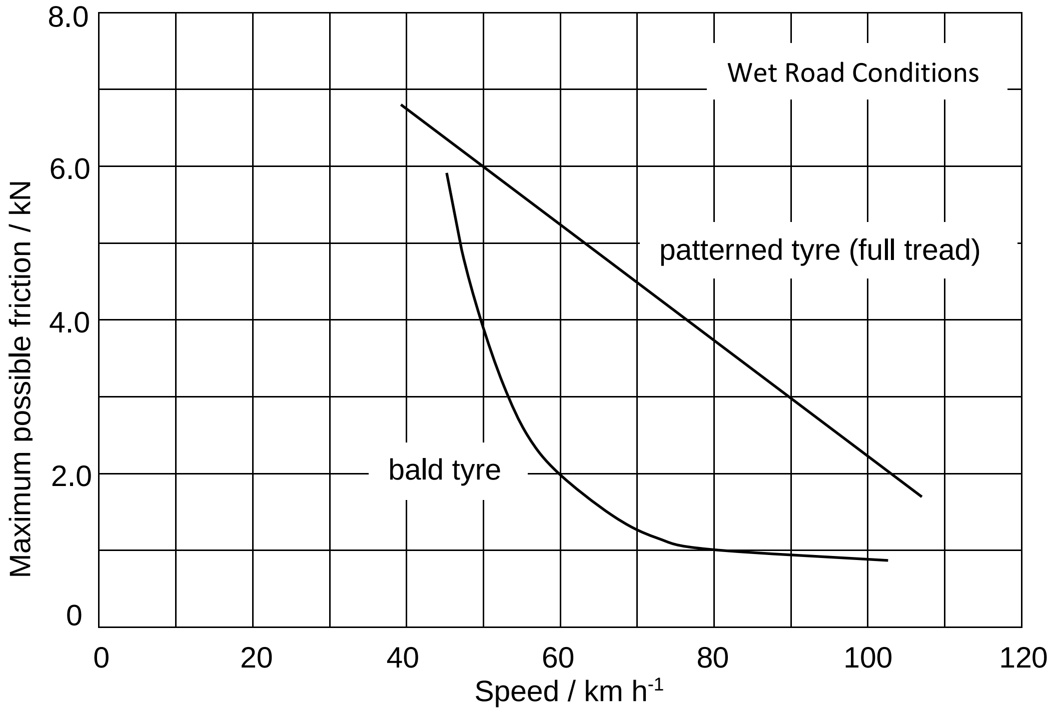


Fig. 8.1

Patterned tyre (full tread)

Fig. 8.2

Bald tyre

Fig. 8.3

(a) Explain why the maximum friction on a patterned tyre (full tread) shown in Fig. 8.2, is greater than that of a bald tyre (Fig. 8.3).

Grooves in patterned tyres expel water away (or channel water out) from beneaththe tyre for more grip / greater frictional force [1]. Bald tyres (no treads) maintains a layer of water between tyre and road surface and has smaller frictional force / Thepresence of water reduces friction [1]. [2]

(b) In addition to the frictional forces between the tyres and the road, the car also experiences air resistance. The air resistance $\mathbf{F_{air}}$ experienced by a car at any speed **v** (in km h^{-1}) is given by the equation:

$$\mathbf{F_{air} = kv^2} \quad \text{, where } \mathbf{k} \text{ is a constant.}$$

A car with patterned tyres (full thread) is moving on a **wet** road at a constant speed of 50 km h^{-1}. The total mass of the car and its passengers is 900 kg. If the air resistance experienced by the car at that speed is 5.0 kN, determine (from Fig. 8.1)

(i) the driving force of the car.

Since car is at constant speed at 50 km h^{-1},
Driving force = Air resistance + Frictional force
= 5.0 kN + 6.0 kN [1]
= 11.0 kN [1]

[2]

(ii) Find the value of the constant **k** when the car is moving at 50 km h^{-1}.

$F_{air} = kv^2$
$5.0\ \text{kN} = k(50\ \text{kmh}^{-1})^2$ **[1]**
$k = 2.0 \times 10^{-3}\ \text{kN km}^{-2}\ \text{h}^2$ **[1] (Unit for this question can be overlooked)**

[2]

(iii) If the car's speed is now increased to a new constant speed of 90 km h^{-1}, determine the new driving force of the car at this constant speed.

At 90 kmh^{-1}, Frictional force = 3.0 kN
$F_{air} = kv^2$
$= 2.0 \times 10^{-3} \times 90^2$
$= 16$ kN **[1]**
Driving force = 16 kN + 3.0 kN
= 19 kN [1]

[2]

(c) A special thermometer is used to measure the temperature of the air, T / °C, by relating it to the air pressure, P / kPa within a certain range of pressure. The relationship is given by:

$$P = k\,T + c$$

where k and c are constants

Some the pressure and temperature values of the air in the tyre are shown in Table 8.

P / kPa	T / °C
170	20.0
240	70.0

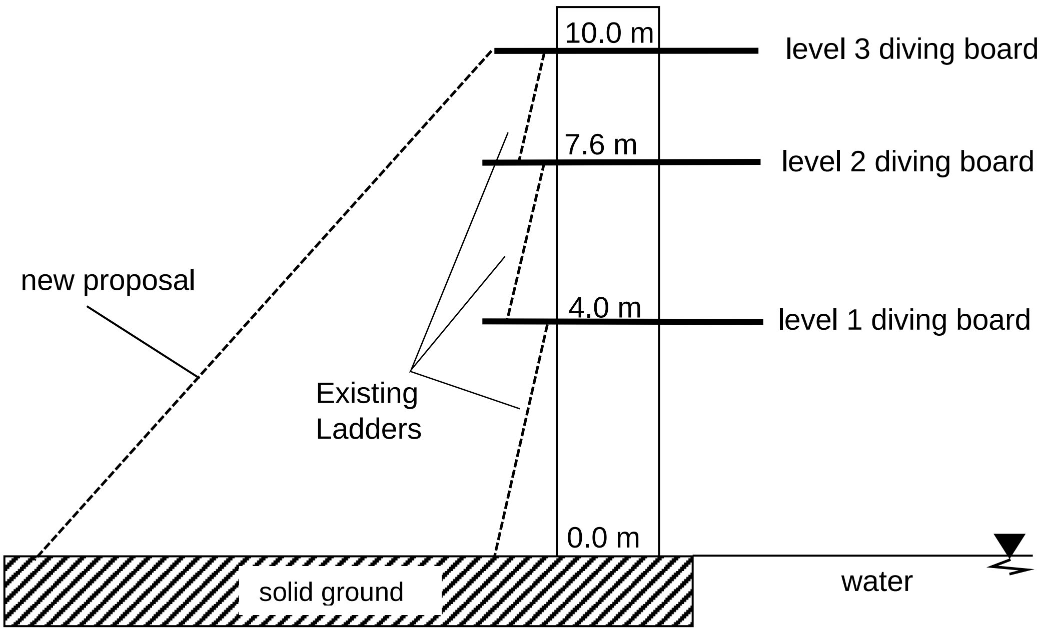
Table 8

Calculate the temperature of the air in the tyre when the pressure is 200 kPa.

θ = 20.0 + [(200 – 170) / (240 – 170)] x 50.0 [1]
= 20.0 + 21.4
= 41.4 ˚C [1]

[2]

9 There are three diving boards at different heights in a diving pool. Each level is accessible by means of near vertical ladders. Level 1 is 4.0 m, level 2 is 7.6 m and level 3 is 10.0 m from the surface of the water.



(a) Find the gravitational potential energy gained by a diver that has a mass of 47 kg when he climbs from the ground to level 3.

Potential energy gained by diver if he reaches level 3
= mgh
= 47 x 10 x (4.0 + 3.6 + 2.4) [1]
= 4.7 x 10^3 J [1]

[2]

(b) Determine the average effective power if it takes him 35 s to climb up to level 3.

Average effective power = potential energy gained/time
= 4700 / 35 [1]
= 134.3
= 1.3 x 10^2 W [1]

[2]

(c) A diver dives from level 3 into the water. Calculate his speed just before he hits the surface of the water.

From Conservation of Energy,
Loss in gravitational P.E. = Gain in K.E.
47 x 10 x 10 = ½ (47) v^2 [1]
v = 14 m/s [1]

[2]

(d) Explain if there is any work done by gravity as a man walks along level 1.

No work is done by the weight of the man [1] when he is walking along level 1because his weight and his direction of displacement are perpendicular to other [1].

[2]

(e) A new proposal involves building an incline stairs that runs directly from the ground to level 3. It allows divers to go walk up a gentler incline instead of the existing near vertical climb.

Explain if the new proposal will reduce the work done by the diver against gravity.

No / there is no reduction in the potential energy [1]. the work done against gravity is independent of the path of the displacement or the potential energy depends only on the height of level 3 from the ground [1].

[2]

EITHER

10A When a spacecraft returns to Earth from space, it must first re-enter the atmosphere. A high speed spacecraft has a very large amount of kinetic energy. As it is slowed down, the kinetic energy is converted into thermal energy. The temperature rise during re-entry is a major problem for spacecraft designers—the astronauts inside must not be cooked! During the re-entry of the American Mercury capsules, the air outside the capsule reach a temperature of 5260°C and turned an orange colour. The outside of the capsule itself reached a temperature of 1648°C.

(a) A special resin (a solid or highly viscous substance), on a fiberglass screen, was applied to the surface. The resin boiled and vapourised during this re-entry journey.

Explain the purpose of this special resin coating on the surface of the American Mercury capsules.

The function of the resin is to absorb the thermal energy which the spacecraft may absorbed [1]. When the resin evaporates / boils it takes away large amount of heat energy, latent heat of vaporization [1].

[2]

(b) The space shuttle uses special silica tiles to protect it. The bottom and the leading edge are covered with glossy black tiles and a black reinforced carbon material covers the nose and wing leading edges.

Fig. 10.1

Comment on the following properties of the silica tiles used to cover the outer surface of a spacecraft as shown in Fig. 10.1:

(i) Colour (black or white);

The black coloured object / surface helps to dissipate heat away from space shuttle [1] since black coloured object / surface is a good radiator of heat [1].

OR

The white coloured object / surface helps to reflect away heat [1] generated externally due to friction since white coloured object / surface is a good reflector of radiation [1].

[2]

(ii) Large specific heat capacity;

The silica tiles should have a very high specific heat capacity so that itrequires a very large amount of thermal energy to raise the temperature of one unit mass of the silica tiles by 1°C [1], this will keep the temperature of the surface lower [1].

[2]

(iii) Poor thermal conductivity.

The silica tiles is a good thermal insulator or poor conductor of heat. This helps to insulate the inside of the space shuttle from the extreme temperature [1].

[1]

(c) During the launch of the NASA space shuttle, the used rocket thruster will be ejected just before the space shuttle exit the atmospheric layer. An aluminium section (boiling point of 2467 °C) of a used rocket thruster has a mass of 1.0 kg. It returns to Earth at a speed of 5000 m s^{-1}.

(i) By assuming that all its kinetic energy is converted into thermal energy as it enters the atmosphere, find the temperature rise of the section. (The specific heat capacity of aluminium is 900 J kg^{-1}°C^{-1})

$\frac{1}{2} mv^2 = mc\Delta\theta$

$\frac{1}{2}$ (1.0 kg) (5000 m/s)^2 = (1.0 kg) (900 J/kg/°C) $\Delta\theta$ **[1]**

$\Delta\theta$ = 1.4 x 10^4 °C

The rise in temperature is 1.4 x 10^4 °C. [1]

[2]

(ii) Explain why such small sections of the rocket thruster would not be likely to be found on the surface of the Earth.

The rise in temperature is much higher than the boiling point (2467°C) of aluminium / hence the aluminium sections would have vaporized into the air [1].

[1]

OR

10B Read the following passage about a steam wax extractor and answer the questions that follow.

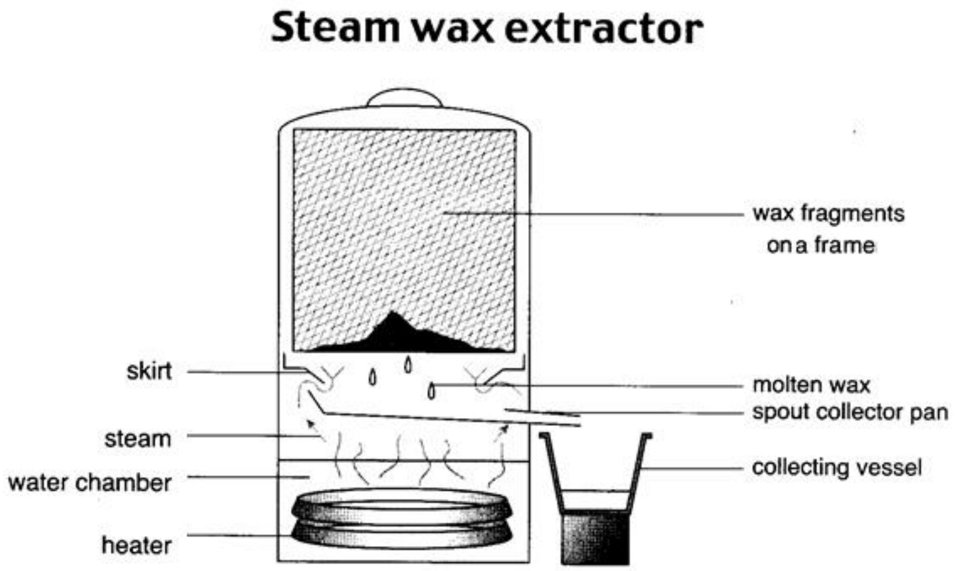


Fig. 10.2

Beeswax is the main component of the honeycomb build by honey bees. Uses of Beeswax includes making candles, furniture polish and even cosmetics. In modern bee farms, honey bees will build honey combs in wooden frames that can be removed from a bee hive. After the honey is extracted from the combs, the beeswax can be collected using a wax extractor.

A steam wax extractor consists of a water chamber where water is boiled by a gas or electric heater. The spout collector pan allows the molten wax and condensed steam to run out into a collecting vessel. The skirt above the spout collector pan that deflects any molten wax into the pan rather than falling into the boiling water below. A steam wax extractor, shown in Fig. 10.2, is a simple and an effective tool to extract wax from honeycombs, as beeswax absorbs vapour and becomes molten wax.

Beeswax melts at 63 °C and its *specific latent heat of fusion* is 1.7×10^5 J kg^{-1} which is only about 8.0 % *specific latent heat of vaporization* of water.

(a) Explain why steam is a better medium to melt beeswax than boiling water.

Steam is a gas which can move / diffuse into the wax fragments easily [1]. It also releases large amount of latent heat when it condenses [1].

Or

Boiling water can melt the wax and create more separation process [1].

[2]

(b) Define the term *specific latent heat of fusion.*

Specific latent heat of fusion is defined as the amount of heat required to change a substance of mass 1 kg from solid to liquid or liquid to solid without any change in temperature [1].

[1]

(c) Using the information above and given that the specific latent heat of vaporization and specific heat capacity of water are 2.26×10^6 J kg^{-1} and 4200 J kg^{-1} K^{-1} respectively, estimate the maximum mass of beeswax melted by 0.100 kg of steam at 100 °C.

Heat released by steam $= ml + mc\theta$
$= (0.100 \times 2.26 \times 10^6) + (0.100 \times 4200 \times (100 - 63))$ **[1]**
$= 241\,540$ J **[1]**

Mass of beeswax melted $= Q / l$
$= 241\,540 / 1.70 \times 10^5$ **[1]**
$= 1.42$ kg **[1]**

[4]

(d) Using ideas from molecular theory, describe what happens to the wax molecules during melting.

Wax molecules gain potential energy from steam molecules. They vibrate about their equilibrium positions so vigorously / greater vibration [1] and the wax molecules changed from being in fixed position to sliding / rolling [1], forming a liquid.

[2]

(e) Suggest one way to increase the efficiency of extracting wax using this steam wax extractor, without increasing the power of the heater.

Cover the top of the extractor to prevent any steam from escaping

OR

Use lagging material to wrap the extractor to reduce heat loss [1].

[1]

END OF PAPER